INTERSTATE 405 Corridor Program

Congestion Relief & Bus Rapid Transit Projects

APPENDIX T8

WSDOT Power Supply Design for Transportation Applications

I-405, SR520 to SR522 Stage 1 (Kirkland Stage 1)

Request For Proposal

July 15, 2005

Washington State Department of Transportation

Line Loss

WSDOT

Fall / Winter 2004

Presented by: Keith Calais

OHM'S LAW

P = Watts (Power)
I = CURRENT (AMPERES)
R = RESISTANCE (OHMS)
E = ELECTROMOTIVE FORCE (VOLTS)

$P = EI$ WATTS = AMPERES X VOLTS

$I = \frac{E}{R}$ $\text{AMPERES} = \frac{\text{VOLTS}}{\text{OHMS}}$

$R = \frac{E}{I}$ $\text{OHMS} = \frac{\text{VOLTS}}{\text{AMPERES}}$

$E = IR$ VOLTS = AMPERES X OHMS

P = WATTS

$$\text{WATTS} = \frac{\text{VOLTS}^2}{\text{OHMS}}$$

$$\text{WATTS} = \text{AMPERES}^2 \times \text{OHMS}$$

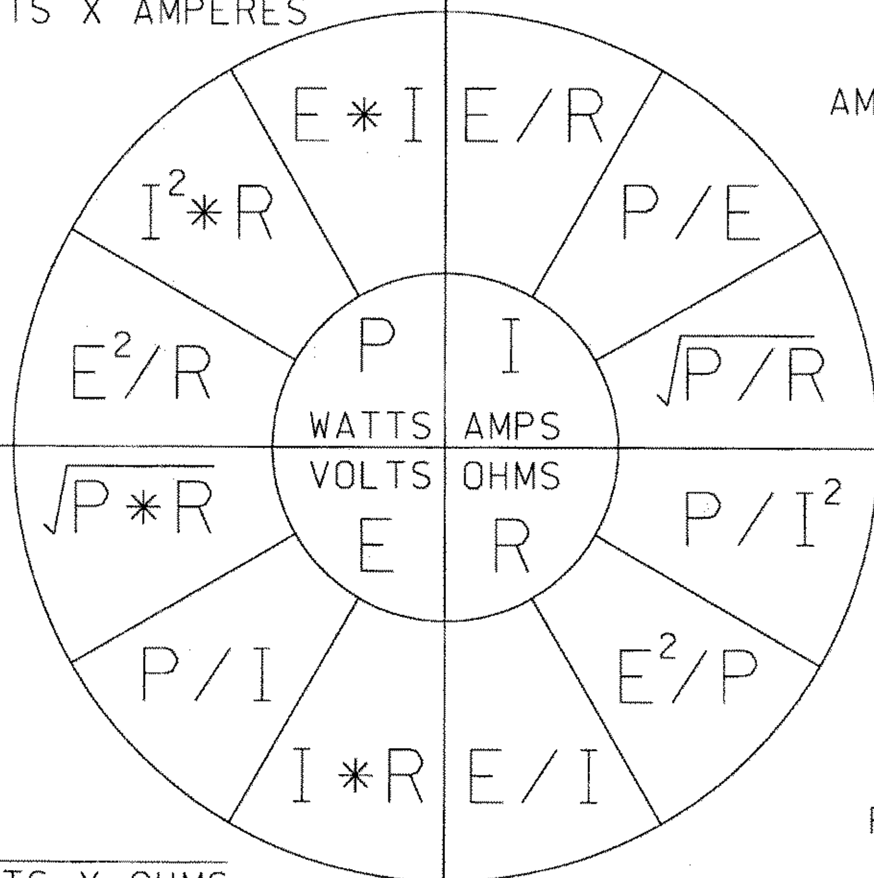
$$\text{WATTS} = \text{VOLTS} \times \text{AMPERES}$$

I = AMPERES

$$\text{AMPERES} = \frac{\text{VOLTS}}{\text{OHMS}}$$

$$\text{AMPERES} = \frac{\text{WATTS}}{\text{VOLTS}}$$

$$\text{AMPERES} = \sqrt{\frac{\text{WATTS}}{\text{OHMS}}}$$



E = VOLTS

$$\text{VOLTS} = \sqrt{\text{WATTS} \times \text{OHMS}}$$

$$\text{VOLTS} = \frac{\text{WATTS}}{\text{AMPERES}}$$

$$\text{VOLTS} = \text{AMPERES} \times \text{OHMS}$$

R=OHMS

$$\text{OHMS} = \frac{\text{VOLTS}}{\text{AMPERES}}$$

$$\text{OHMS} = \frac{\text{VOLTS}^2}{\text{WATTS}}$$

$$\text{OHMS} = \frac{\text{WATTS}}{\text{AMPERES}^2}$$

Clear Catinkus for PIER (Power)

- (I) Current is what flows on a wire or conductor like water flowing down a stream. Current flows from points of high voltage to points of low voltage on the surface of a conductor. Current is measured in (A) amperes or amps.

  (E) Voltage is the difference in electrical potential between two points in a circuit. It's the pressure or push behind current flow through a circuit, and is measured in (V) volts.

  (R) Resistance determines how much current will flow through a component. Resistors are used to control voltage and current levels. A very high resistance allows a small amount of current to flow. A very low resistance allows a large amount of current to flow. Resistance is measured in ohms.

  (P) Power is the amount of current times the voltage level at a given point measured in wattage or watts.

Example

- A circuit having a resistance of 5 ohms is under a pressure of 110 volts. How much current will flow?
- amperes = volts / resistance
- amperes = 110 volts / 5 ohms
- answer = <u>22 amperes</u>

Example

- If the resistance of a circuit is 10 ohms, what is the voltage necessary for a flow of 20 amperes?
- volts = amperes x ohms
- volts = 20 amperes x 10 ohms
- Answer = <u>200 volts</u>

Example

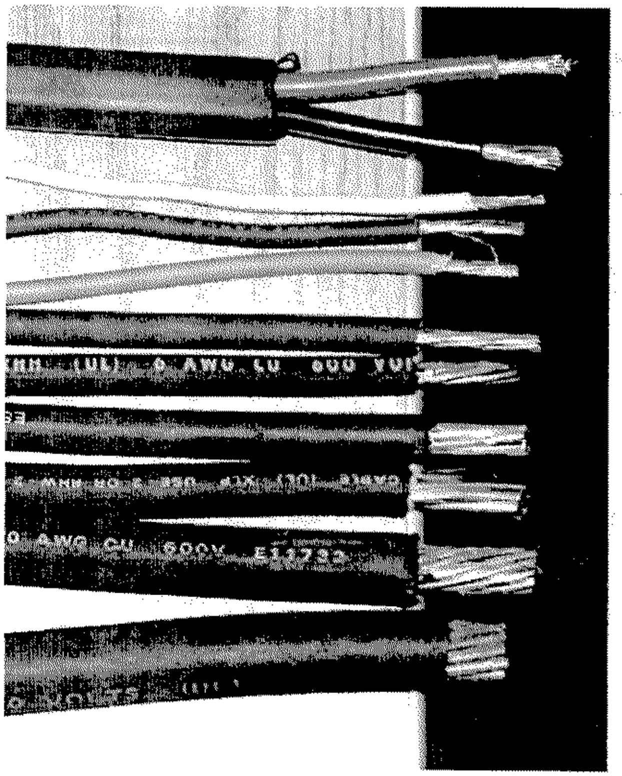
- On a 110 volt circuit what resistance is necessary to obtain a flow of 15 amperes?
- ohms = volts / amperes
- ohms = 110 volts / 15 amperes
- Answer = <u>7.33 ohms</u>

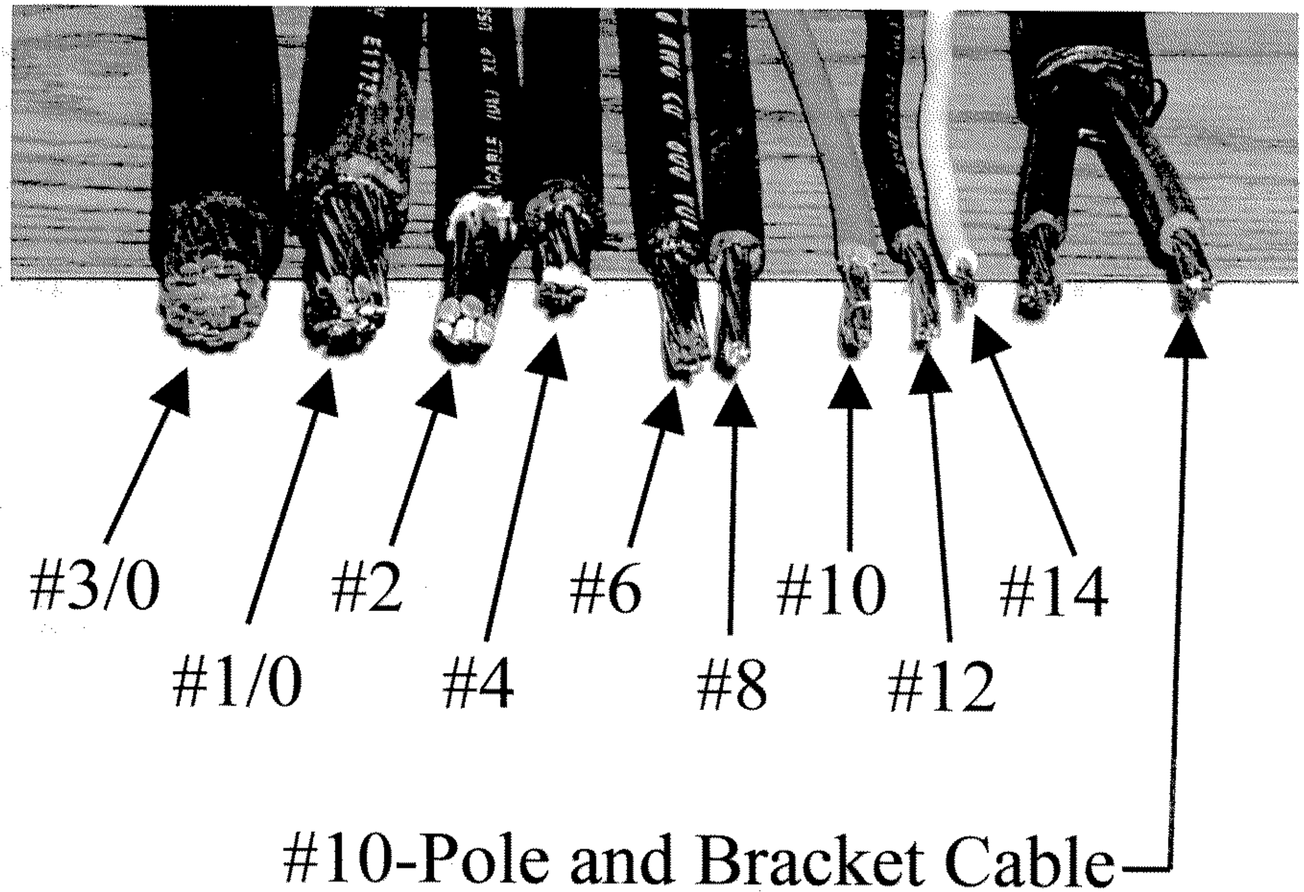
Example

- A water heater is served by a 240 volt circuit. The heating element is 4500 watts. What is the load on this circuit?
- 4500 watt heating element / 240 volts = 18.75 amps
- On this circuit, what resistance is necessary within the heating element to obtain the flow of 18.75 amperes?
- ohms = volts / amperes
- ohms = 240 volts / 18.75 amperes
- Answer = <u>12.80 ohms</u>

Electrical Energy Unit Conversions

- 1 watt = 1 volt x 1 ampere
- watts = volt amperes
- 1 ampere = 1 watt / 1 volt
- 1 volt = 1 watt / 1 ampere
- k = 1000 (accepted convention that "k" indicates 1000) NEC 110-6, comments
- ___ watts / 1000 = ___ kilo volt ampere (kVA)
- ___ kVA x 1000 = ___ watts (or volt amperes)
- <u>1,528</u> watts / 1000 = <u>1.528</u> kVA
- <u>3.224</u> kVA x 1000 = <u>3,224</u> watts (or volt amperes)





#3/0
#1/0
#2
#4
#6
#8
#10
#12
#14
#10-Pole and Bracket Cable

What is Line Loss?

- Line Loss is the voltage drop (Vd) between the electrical service and the load. Line loss usually controls wire size determination rather than the allowable ampacities listed in Chapter 3 of the National Electrical Code.

- Recommended allowable voltage drop is discussed in 2002 NEC article 210.19, FPN No.4

Why do we need to worry about Voltage Drop?

- If you have too much Voltage Drop on a circuit, the equipment you are trying to power may not work.

- Inefficiency equals using more power and receiving less output. (see reasonable operating efficiency commentary after NEC 2002 Article 215.2 in the handbook)

- You need to make sure you have enough capacity for future use. (Figure 3-4% for future Illumination loads and 1-2% for future ITS loads.)

Maximum Voltage Drop Requirements

- **High Pressure Sodium** - ultimate loads known Vd = 8%, unknown Vd = 5%.
- **Metal Halide** - ultimate loads known Vd = 8%, unknown Vd = 5%.
- **Mercury Vapor** - ultimate loads known Vd = 10%, unknown Vd = 5%.
- **Temporary Illumination System** (installed & removed within same contract) - Vd = 10%.
- **Traffic Signal** - Vd = 5%.
- **ITS System** - Vd = 3%

Wire size

- On new ITS circuits pick your wire size so that you have **2-3%** voltage drop.
- On new illumination circuits (ultimate load unknown) pick your wire size so that you have **4-5%** voltage drop.
- On new signal circuits pick your wire size so that you have **4-5%** voltage drop.
- On existing ITS circuits where you are replacing the wire the maximum voltage drop allowed is **3%**.
- On existing signal circuits where you are replacing the wire the maximum voltage drop allowed is **5%**.
- On existing illumination circuits (ultimate load known) where you are replacing the wire the maximum voltage drop allowed is **8%**.

How do we calculate Voltage Drop?

In order to calculate line loss you need to know:

This formula: **Vd = 2ALR**

Where:
Vd= Voltage Drop.
2 = because the power goes out and back using two wires.
A = **load** being drawn. (Amperes)
L = **distance** the load is being carried. (Feet)
R = **resistance** per foot of wire used. (Ohms) When looking up the "R" factor in the chart you need to know two things:

- The **wire size** carrying the load. (#2, #4, #6, #8, etc.)
- The **type of wire** being used. (**Copper** or Aluminum)

Conductor Size, cross-sectional area, amperage capacity and resistance chart

Size (AWG)	X-Section (Square Inches)	(Amps)	Copper (ohms/foot)	Aluminum (ohms/foot)
250 Kcmil	0.4596	255	0.000054	
4/0	0.3718	230	0.000063	
3/0	0.3117	200	0.000080	
2/0	0.2624	175	0.000101	
1/0	0.2223	150	0.000127	
1	0.1900	130	0.000160	
2	0.1333	115	0.000201	
4	0.0973	85	0.000321	0.000509
6	0.0726	65	0.000510	0.000807
8	0.0556	50	0.000809	0.001280
10	0.0330	30*	0.001290	
12	0.0260	20*	0.002051	
14	0.0210	15*	0.003261	
	NEC, Chapter 9, Table 5 - Type RHW conductors	NEC, Table 310.16 *reduced per Article 240.4(D)	NEC Chapter 9, Table 8	NEC Chapter 9, Table 8

Calculating the distance between loads

- Scale off the distance between each load or the distance between the load and the service.
- Add 5' when entering the service cabinet or another cabinet to power.
- Add 10' per in-grade junction box that the wire passes through. This takes into account the conduit sweeps and the 3' of slack wire.
- Add 5' to each side of wire run (instead of 10') when there is a splice in the junction box.
- Add 5' for the sweep into the luminaire and up to the handhole.
- Add 5' for NEMA 3 or NEMA 4X junction boxes.
- Add 2' to each side of wire run (instead of 5') when there is a splice in the NEMA junction box.
- Add 52' (for 40' pole with 16' mast arm) or 62' (for 50' pole with 16' mast arm) to the distance to accommodate for the last luminaire pole and mast arm on each run. Use a #10 wire (pole & bracket cable) for this distance.
- Add 2' to enter terminal cabinet and terminate conductor on terminal block.

Different Types of Loads

- There are three different types of loads that we calculate.
  - 1.) Intelligent Transportation System (ITS), previously SC&DI
  - 2.) Traffic Signal System
  - 3.) Illumination System (including sign lights)
- There are different ways to calculate each of these loads

ITS Loads

An ITS circuit is sized for the ultimate load that can be drawn at one time. This is usually controlled by the rated output of the transformer. If there is **no transformer,** use the figures below to calculate your loads.

Ramp Meter (RM) -720W+1800W(GFCI's)=2520W
Camera Cabinet (CC) -324W+1800W(GFCI's)=2124W
Data Station (ES) -252W+1800W(GFCI's)=2052W
Highway Advisory Radio Station (HAR)-200W+1800W(GFCI's)=2000W
Variable Message Sign (VMS)-Contact the ITS designer because each sign requires a different loading. If you are the ITS designer contact the manufacturers for like size and type VMS Sign data.

(Generally, if the load is below 1800 watts, there is not an included GFCI load.) If the load is larger than 1800 watts, then a GFCI load is assumed to be included.
Consult with ITS designers to let them know this is your intention and to make sure this will be adequate. If you are the designer, please keep this in mind.)

ITS loads - Example

The basic way a load is calculated is by dividing the wattage (Volt Amperes) by the voltage serving the load.

$$\frac{2520W(\text{or } 2.52kVA)}{\mathbf{120V}} = 21.0Amps$$

$$\frac{2520W(\text{or } 2.52kVA)}{\mathbf{240V}} = 10.5Amps$$

$$\frac{2520W(\text{or } 2.52kVA)}{\mathbf{480V}} = 5.25Amps$$

$$\frac{7500W(\text{or } 7.5kVA)}{\mathbf{120V}} = 62.5Amps$$

$$\frac{7500W(\text{or } 7.5kVA)}{\mathbf{240V}} = 31.25Amps$$

$$\frac{7500W(\text{or } 7.5kVA)}{\mathbf{480V}} = 15.625Amps$$

Signal Loads

A Signal circuit is sized for the ultimate load that can be drawn at one time. This is usually the **sum** of the items below:

300W ------ **Controller**

1800W ----- **2-GFCI's** (receptacles - vent fan & cabinet light(s) are included within this load)

116W ------- multiply by the Total # of **Pedestrian Displays**

165W for 12" heads (signal displays) **or**

69W for 8" heads (flashing beacon displays)-multiply by the **Total # of Vehicle Display Lamps** illuminated at one time (1 Lamp per 3 section display, 2 Lamps per 4 or 5 section display) (and yes, we know LED's draw much less wattage)

USE THESE NUMBERS FOR SIZING CONDUCTORS.

Signal Loads - Example

For a **<u>"T" intersection</u>** use 9-vehicle heads, and 6-pedestrian heads.

$$300W+1800W+(9*165W)+(6*116W)=4281W$$

$$\frac{4281W}{120V}=35.675Amps$$

For a **<u>four legged intersection</u>** use 12-vehicle heads, and 8-pedestrian heads.

$$300W+1800W+(12*165W)+(8*116W)=5008W$$

$$\frac{5008W}{120V}=41.73Amps$$

If there are supplemental heads used in your design these values may be larger. Use these values as a minimum.

Illumination Loads

Each luminaire has a different lamp load factor depending on what **wattage** lamp and what **voltage** you are using. You have to check the manufacturers catalog cuts to see what voltage the particular luminaire draws during it's "start-up" period. This is roughly the same as **multiplying the wattage by 1.2 then dividing by the serving voltage**, but the catalog values are more accurate. These are the numbers from the GE catalog.

Bulb Wattage	Load@ 240V (AMPS)	Load@ 480V (AMPS)
100	0.6	0.3
150	0.9	0.5
175*	0.9	0.5
200	1.1	0.6
250	1.4	0.7
310	1.7	0.9
400	2.1	1.1

* Mercury Vapor

Flashing Beacons

- 8" Lens – incandescent
- 1 lamp = 69 watts
- 2 lamps = 138 watts
- 4 lamps = 276 watts
- 8" Lens – LED
- 1 lamp = 15 watts
- 2 lamps = 30 watts
- 4 lamps = 60 watts

- 12" Lens – incandescent
- 1 lamp = 165 watts
- 2 lamps = 330 watts
- 4 lamps = 600 watts
- 12" Lens – LED
- 1 lamp = 25 watts
- 2 lamps = 50 watts
- 4 lamps = 100 watts

•The dimmable flashing unit draws 0.005 amps at 120 volts. For line loss calculation purposes, you can ignore the dimming flasher unit load.

•A large majority of existing flashers have 1 or 2 eight inch lens. The need would have to be great before you would use twelve inch lens.

Illumination Load Examples

Illumination Circuit A load

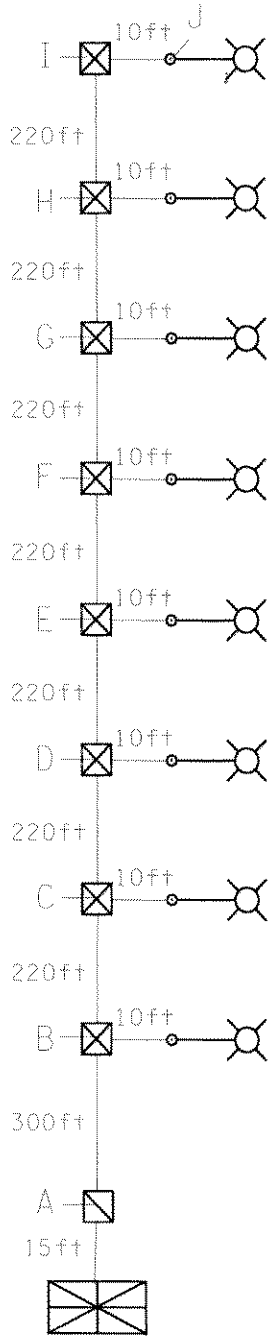
8-400 watt, HPS Luminaires, 240 VAC, 2.1 Amps per luminaire

8 x 2.1 amps = 16.8 Amps

Illumination Circuit B load

11-400 watt, HPS Luminaires, 240 VAC, 2.1 amps per luminaire

11 x 2.1 amps = 23.1 amps



Notes:

1.) Add 10 ft of length for each junction box.

2.) All Luminaires are HPS 400Watt Type III Medium Cutoff.

3.) All luminaires are mounted on 50ft Light Standards.

4.) Double mast arm lengths are 12ft.

5.) Single mast arm lengths are 16ft.

CIRCUIT A

Voltage Drop for Circuit A - 1st try

Vd=2ALR

Total length of Segment

Total load on Segment

Wire out and Back

Resistance of #8 conductor

Service to B	=2(16.8)(5+15+10+300+5=335)(0.000809)	=9.106104
B to C	=2(14.7)(5+220+5=230)(0.000809)	=5.470458
C to D	=2(12.6)(5+220+5 =230)(0.000809)	=4.688964
D to E	=2(10.5)(5+220+5 =230)(0.000809)	=3.907470
E to F	=2(8.4)(5+220+5 =230)(0.000809)	=3.125976
F to G	=2(6.3)(5+220+5 =230)(0.000809)	=2.344482
G to H	=2(4.2)(5+220+5 =230)(0.000809)	=1.562988
H to I	=2(2.1)(5+220+5=230)(0.000809)	=0.781494
I to J	=2(2.1)(5+10+5=20)(0.000809)	=0.067956
J to Light	=2(2.1)(62)(0.001290)	=0.335916
		31.391808

Resistance of #10 conductor

31.391808 /240=0.130799*100=13.1% Vd

13.1% > 5% - Try again with larger wire

Voltage Drop for Circuit A – 2ND try

Vd=2ALR

Total load on Segment

Wire out and Back

Total length of Segment

Resistance of #4 conductor

Service to B	=2(16.8)(5+15+10+300+5=335)(0.000321)	=3.613176
B to C	=2(14.7)(5+220+5 =230)(0.000321)	=2.170602
C to D	=2(12.6)(5+220+5 =230)(0.000321)	=1.860516
D to E	=2(10.5)(5+220+5 =230)(0.000321)	=1.550430
E to F	=2(8.4)(5+220+5 =230)(0.000321)	=1.240344
F to G	=2(6.3)(5+220+5 =230)(0.000321)	=0.930258
G to H	=2(4.2)(5+220+5 =230)(0.000321)	=0.620172
H to I	=2(2.1)(5+220+5=230)(0.000321)	=0.310086
I to J	=2(2.1)(5+10+5=20)(0.000510)	=0.042840
J to Light	=2(2.1)(62)(0.001290)	=0.335916
		12.674340

Resistance of #6 conductor

Resistance of #10 conductor

12.674340/240=0.052810*100=5.3% Vd

5.3% > 5% - Try again with larger wire

Voltage Drop for Circuit A – 3RD try

Total load on Segment

Wire out and Back

$$Vd=2ALR$$

Total length of Segment

Resistance of #2 conductor

Service to B=2(16.8)(5+15+10+300+5=335)(0.000201)=2.262456

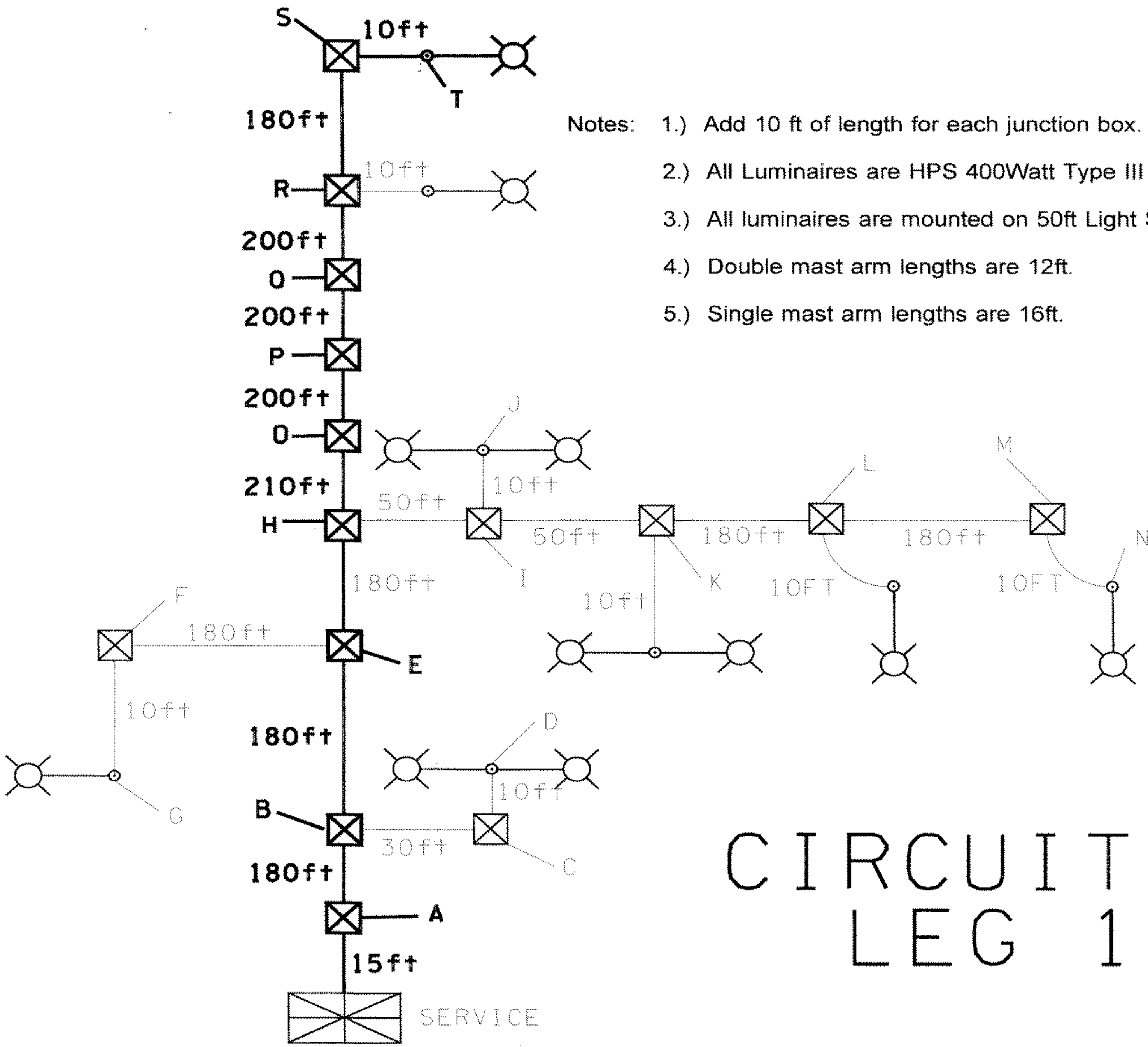
B to C	=2(14.7)(5+220+5=230)(0.000201)	=1.359162
C to D	=2(12.6)(5+220+5 =230)(0.000201)	=1.164996
D to E	=2(10.5)(5+220+5 =230)(0.000201)	=0.970830
E to F	=2(8.4)(5+220+5 =230)(0.000201)	=0.776664
F to G	=2(6.3)(5+220+5 =230)(0.000201)	=0.582498
G to H	=2(4.2)(5+220+5 =230)(0.000201)	=0.388332
H to I	=2(2.1)(5+220+5=230)(0.000201)	=0.194166
I to J	=2(2.1)(10+5+5=20)(0.000809)	=0.067956
J to Light	=2(2.1)(62)(0.001290)	=0.335916
		8.102976

Resistance of #8 conductor

Resistance of #10 conductor

8.102976/240=0.0337622*100=3.4% Vd

3.4% < 5% - #2 wire is acceptable



Notes: 1.) Add 10 ft of length for each junction box.

2.) All Luminaires are HPS 400Watt Type III Medium Cutoff.

3.) All luminaires are mounted on 50ft Light Standards.

4.) Double mast arm lengths are 12ft.

5.) Single mast arm lengths are 16ft.

CIRCUIT B
LEG 1

Voltage Drop for Circuit B Leg#1 - 1^{st} try

Vd=2ALR

Total length of Segment

Resistance of #8 conductor

Total load on Segment

Wire out and Back

Service to B=2(23.1)(5+15+10+180+5=215)(0.000809) =8.035797
B to E =2(18.9)(5+180+5=190)(0.000809) =5.810238
E to H =2(16.8)(5+180+5=190)(0.000809) =5.164656
H to R =2(4.2)(5+210+10+200+10+200+10+200+5=850)(0.000809)=5.776260
R to S =2(2.1)(5+180+5=190)(0.000809) =0.645582
S to T =2(2.1)(5+10+5=20)(0.000809) =0.067956
T to Light =2(2.1)(62)(0.001290) =0.335916

25.836405

Resistance of #10 conductor

25.836405/240=0.107652*100=10.8% Vd
10.8% > 5% - Try again with larger wire

Voltage Drop for Circuit B Leg#1 - 2nd try

Total load on Segment

Wire out and Back

$$Vd=2ALR$$

Resistance of #6 conductor

Total length of Segment

Service to B=2(23.1)(5+15+10+180+5 =215)(0.000510)=5.065830
B to E =2(18.9)(5+180+5 =190)(0.000510) =3.662820
E to H =2(16.8)(5+180+5 =190)(0.000510) =3.255840
H to R =2(4.2)(5+210+10+200+10+200+10+200+5=850)(0.000510)=3.641400
R to S =2(2.1)(5+180+5=190)(0.000510) =0.406980
S to T =2(2.1)(5+10+5=20)(0.000809) =0.067956
T to Light =2(2.1)(62)(0.001290) =0.335916
16.436742

16.436742/240=0.068486*100=6.8% Vd
6.8% > 5% - Try again with larger wire

Resistance of #10 conductor

Voltage Drop for Circuit B Leg#1 - 3rd try

Total load on Segment

Wire out and Back

$$Vd=2ALR$$

Total length of Segment

Resistance of #4 conductor

Service to B=2(23.1)(5+15+10+180+5 =215)(0.000321)=3.188493

B to E =2(18.9)(5+180+5 =190)(0.000321) =2.305422

E to H =2(16.8)(5+180+5 =190)(0.000321) =2.049264

H to R =2(4.2)(5+210+10+200+10+200+10+200+5=850)(0.000321)=2.291940

R to S =2(2.1)(5+180+5=190)(0.000321) =0.256158

S to T =2(2.1)(5+10+5=20)(0.000510) =0.042840

T to Light =2(2.1)(62)(0.001290) =0.335916

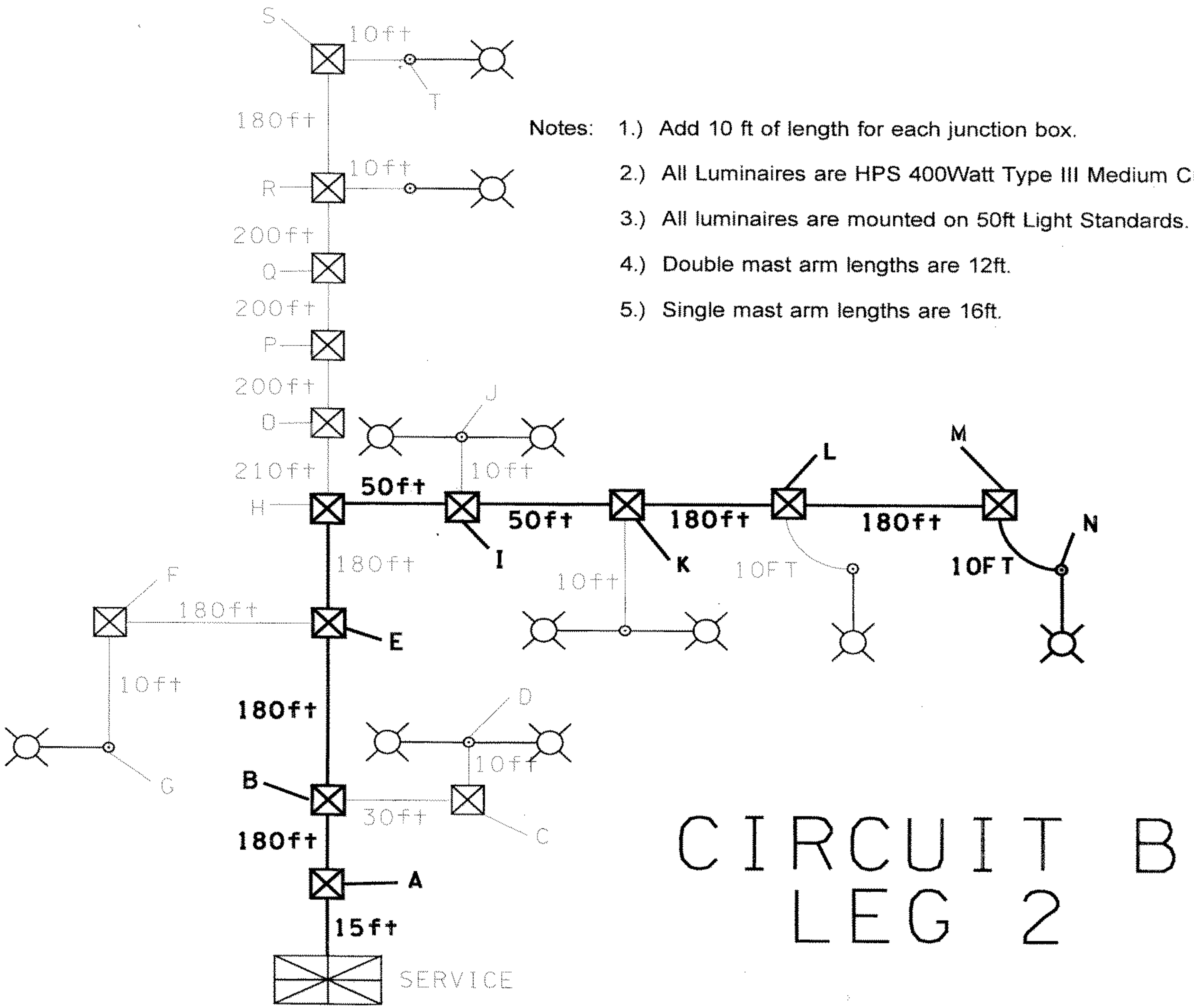
10.470033

Resistance of #6 conductor

Resistance of #10 conductor

10.470033/240=0.043625 *100=4.4% Vd

4.4% < 5% - #4 wire is acceptable



Notes: 1.) Add 10 ft of length for each junction box.

2.) All Luminaires are HPS 400Watt Type III Medium Cutoff.

3.) All luminaires are mounted on 50ft Light Standards.

4.) Double mast arm lengths are 12ft.

5.) Single mast arm lengths are 16ft.

Voltage Drop for Circuit B Leg#2 - 1st Try

Vd=2ALR

Total length of Segment

Resistance of #4 conductor

Total load on Segment

Wire out and Back

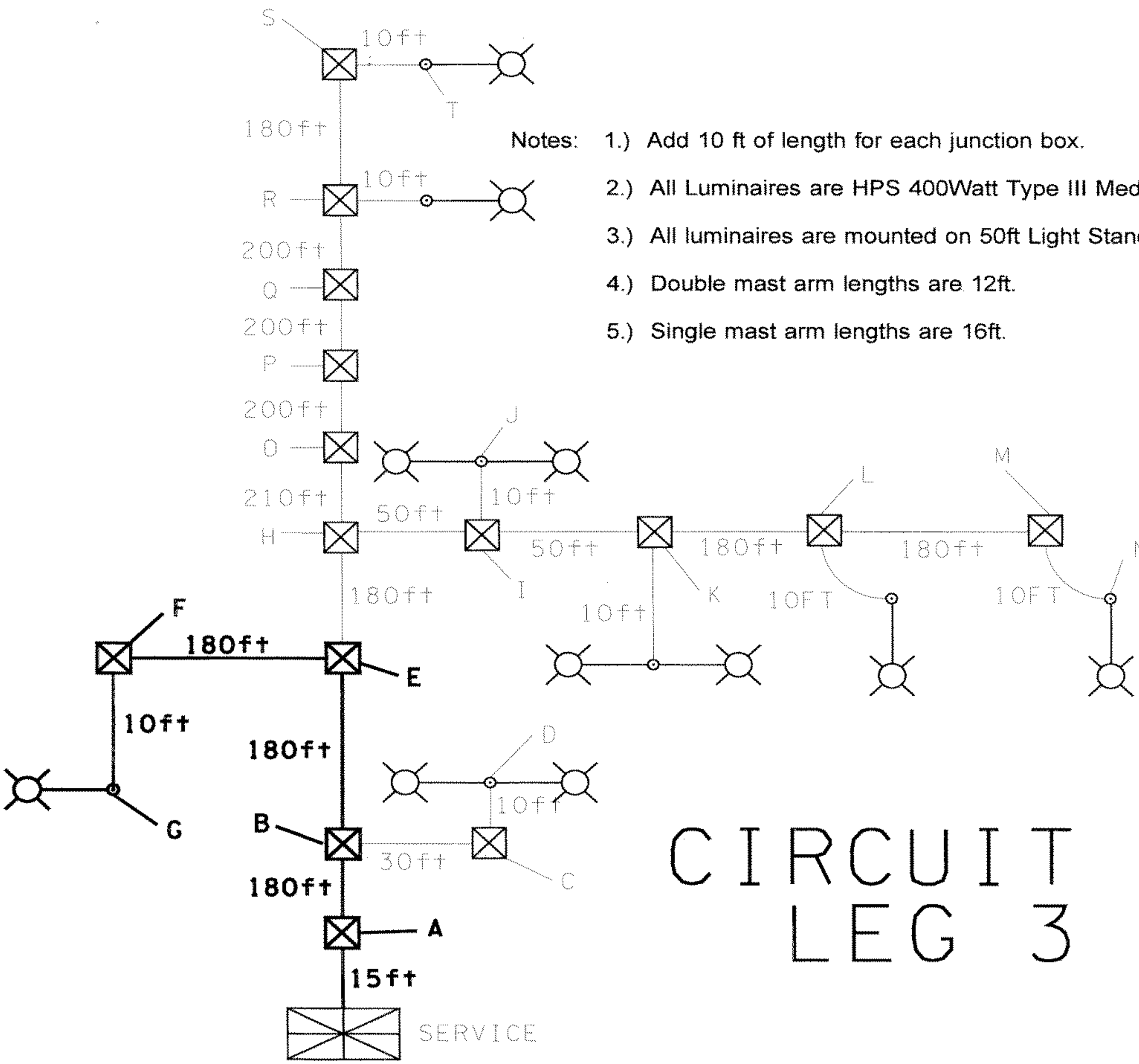
Service to B	=2(23.1)(5+15+10+180+5=215)(0.000321)	=3.188493
B to E	=2(18.9)(5+180+5=190)(0.000321)	=2.305422
E to H	=2(16.8)(5+180+5 =190)(0.000321)	=2.049264
H to I	=2(12.6)(5+50+5=60)(0.000809)	=1.223208
I to K	=2(8.4)(5+50+5=60)(0.000809)	=0.815472
K to L	=2(4.2)(5+180+5=190)(0.000809)	=1.291164
L to N	=2(2.1)(5+180+10+10+5=210)(0.000809)	=0.713538
N to Light	=2(2.1)(62)(0.001290)	=0.335916
		11.922477

Resistance of #8 conductor

Resistance of #10 conductor

11.922477/240=0.049677*100=5.0% Vd

5.0% = 5% - A combination of #4 and #8 wire is acceptable



Notes: 1.) Add 10 ft of length for each junction box.

2.) All Luminaires are HPS 400Watt Type III Medium Cutoff.

3.) All luminaires are mounted on 50ft Light Standards.

4.) Double mast arm lengths are 12ft.

5.) Single mast arm lengths are 16ft.

CIRCUIT B LEG 3

Voltage Drop for Circuit B Leg#3 - 1st try

Vd=2ALR

Total length of Segment

Resistance of #4 conductor

Total load on Segment

Wire out and Back

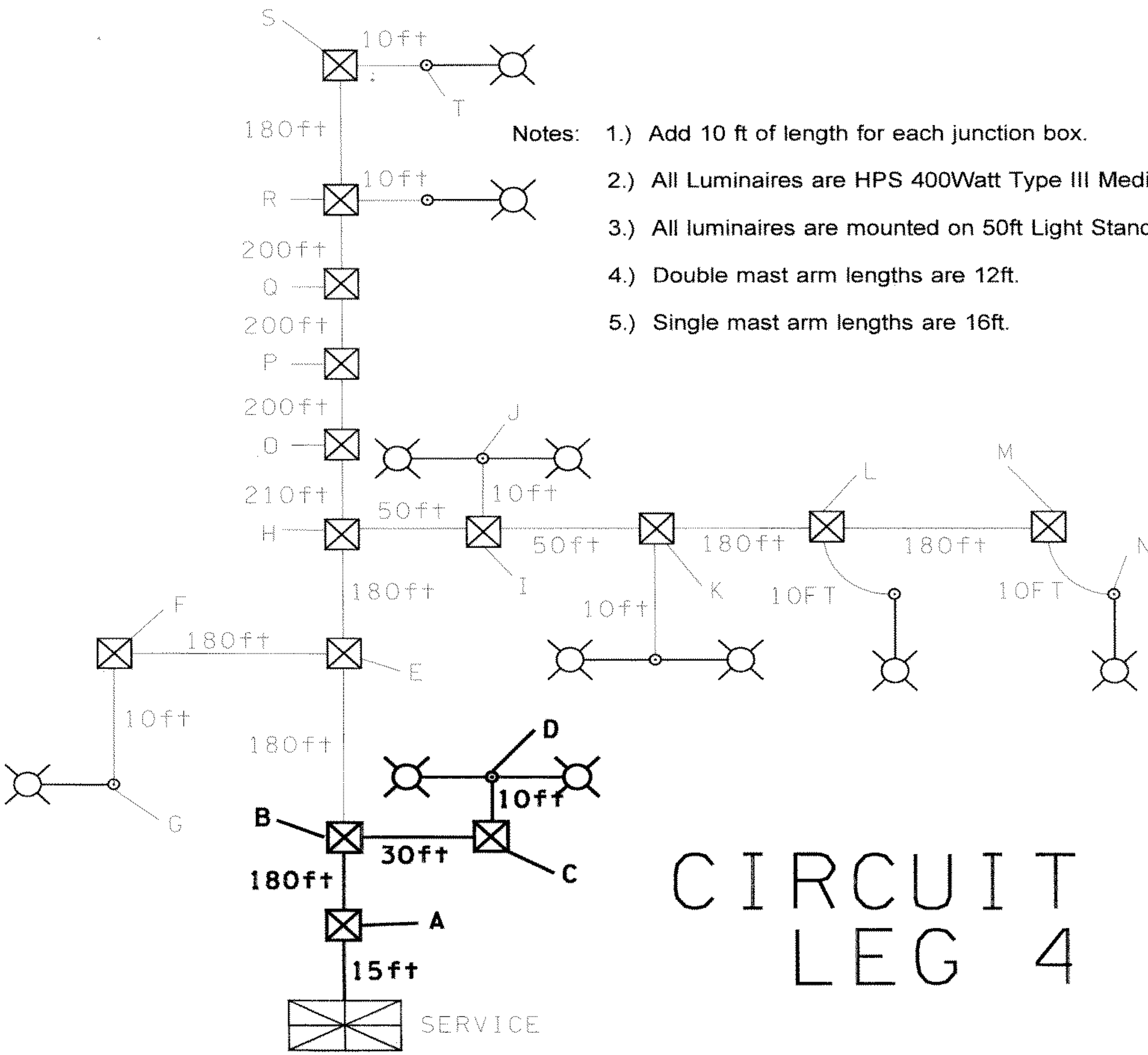
Service to B	=2(23.1)(5+15+10+180+5=215)(0.000321)	=3.188493
B to E	=2(18.9)(5+180+5=190)(0.000321)	=2.305422
E to G	=2(2.1)(5+180+10+10+5=210)(0.000809)	=0.713538
G to Light	=2(2.1)(62)(0.001290)	=0.335916
		6.543369

Resistance of #8 conductor

Resistance of #10 conductor

6.543369/240=0.027264*100=2.7% Vd

2.7% < 5% - A combination of #4 and #8 wire is acceptable



Notes: 1.) Add 10 ft of length for each junction box.

2.) All Luminaires are HPS 400Watt Type III Medium Cutoff.

3.) All luminaires are mounted on 50ft Light Standards.

4.) Double mast arm lengths are 12ft.

5.) Single mast arm lengths are 16ft.

CIRCUIT B LEG 4

Voltage Drop for Circuit B Leg#4 - 1st try

Vd=2ALR

Total length of Segment

Resistance of #4 conductor

Total load on Segment

Wire out and Back

Service to B	=2(23.1)(5+15+10+180+5=215)(0.000321)	=3.188493
B to D	=2(4.2)(5+30+10+10+5=60)(0.000809)	=0.407736
D to Light	=2(2.1)(62)(0.001290)	=0.335916
		3.932145

Resistance of #8 conductor

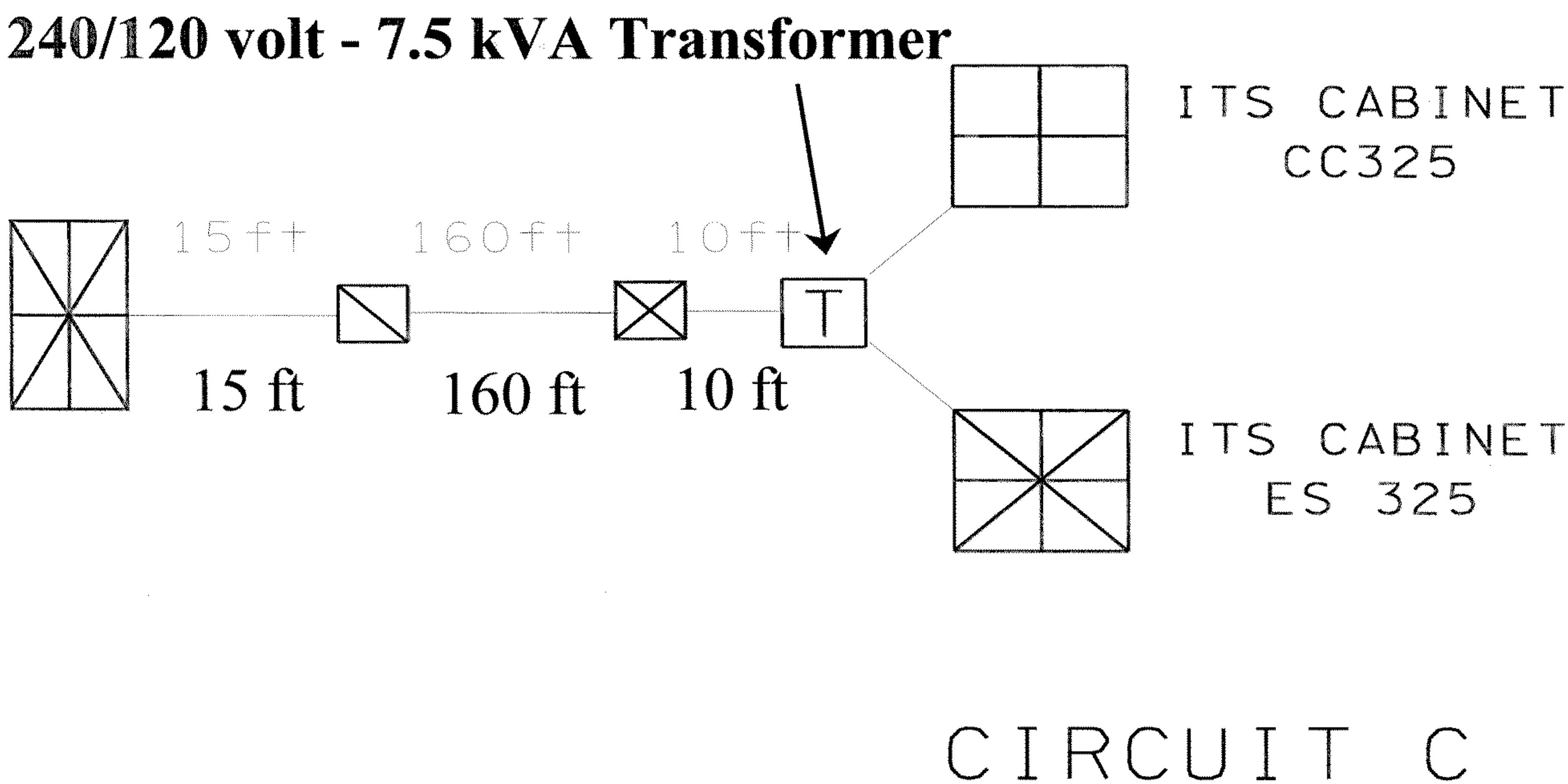
Resistance of #10 conductor

3.932145/240=0.016384*100=1.6% Vd

1.6% < 5% - A combination of #4 and #8 wire is acceptable

Notes: 1.) Add 10 ft of length for each junction box.

2.) Add 5 ft of legnth for each cabinet.



Voltage Drop for Circuit C – 1st try

Vd=2ALR

Given: 240/120 volt - 7.5 kVA transformer.

Find Load: 7.5 kVA x 1000 = 7,500 watts

7,500watts / 240 volts = 31.25 Amps. Load = 31.25 Amps

Total length of Segment

Resistance of #8 conductor

Total load on Segment

Wire out and Back

Service to ES325=2(31.25)(5+15+10+160+10+10+5=215)(0.000809)=10.870938

10.870938/240=0.045296*100=4.5% Vd

4.5% > 3% - #8 wire is not OK

Voltage Drop for Circuit C – 2nd try

$$Vd=2ALR$$

Total length of Segment

Resistance of #6 conductor

Total load on Segment

Wire out and Back

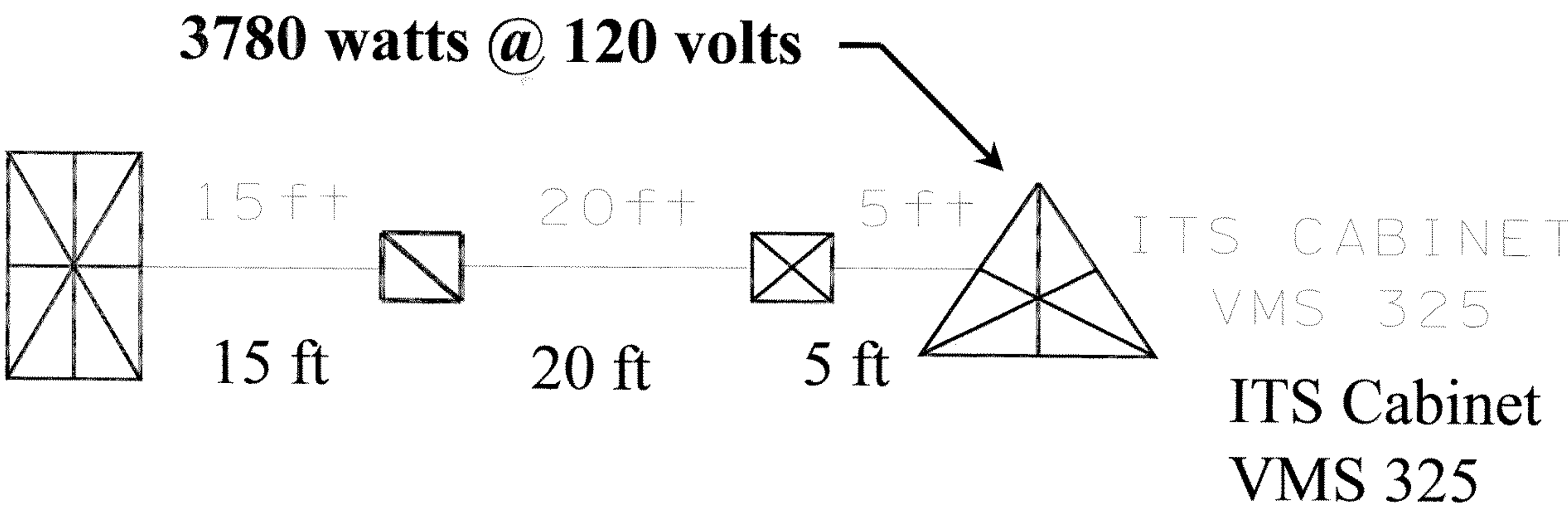
Service to ES325=2(31.25)(5+15+10+160+10+10+5=215)(0.000510)=6.853125

6.853125/240=0.028555*100=2.9% Vd

2.9% < 3% - #6 wire is acceptable

Notes: 1.) Add 10 ft of length for each junction box.

2.) Add 5 ft of legnth for each cabinet.



CIRCUIT D

Voltage Drop for Circuit D

Vd=2ALR

<u>Load equals</u>: 3780 watts / 120 volts = 31.50 Amps

Total length of Segment — Resistance of #8 conductor

Total load on Segment

Wire out and Back

Service to ES326=2(31.5)(5+15+10+20+10+5+5=70)(0.000809)=3.567690

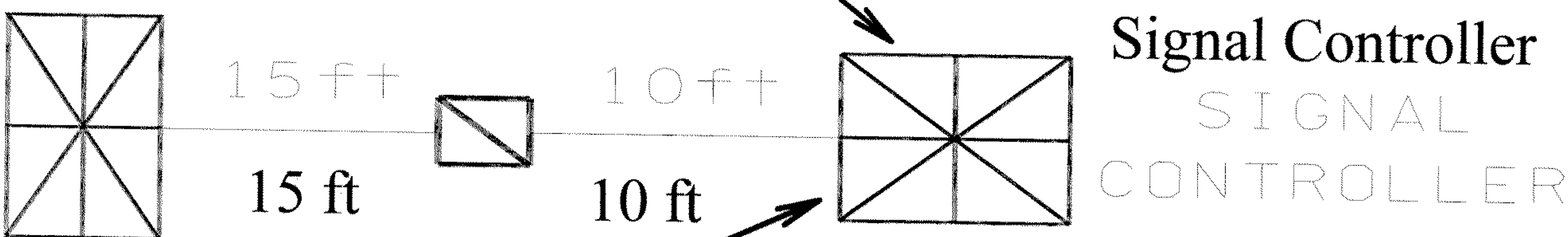
3.567690/120=0.029731*100=3.0% Vd

3% = 3% - #8 wire is acceptable

Notes: 1.) Add 10 ft of length for each junction box.

2.) Add 5 ft of legnth for each cabinet.

5008 watts @ 120 volts



Note: This Traffic Signal Controller serves the four legged intersection as calculated on slide 19. The load is 5008 watts divided by 120 volts equals 41.73 amps.

CIRCUIT E

Voltage Drop for Circuit E

$$Vd=2ALR$$

Total length of Segment

Resistance of #8 conductor

Total load on Segment

Wire out and Back

Service to Sig. Cabinet=2(41.73)(5+15+10+10+5=45)(0.000809)=3.038361

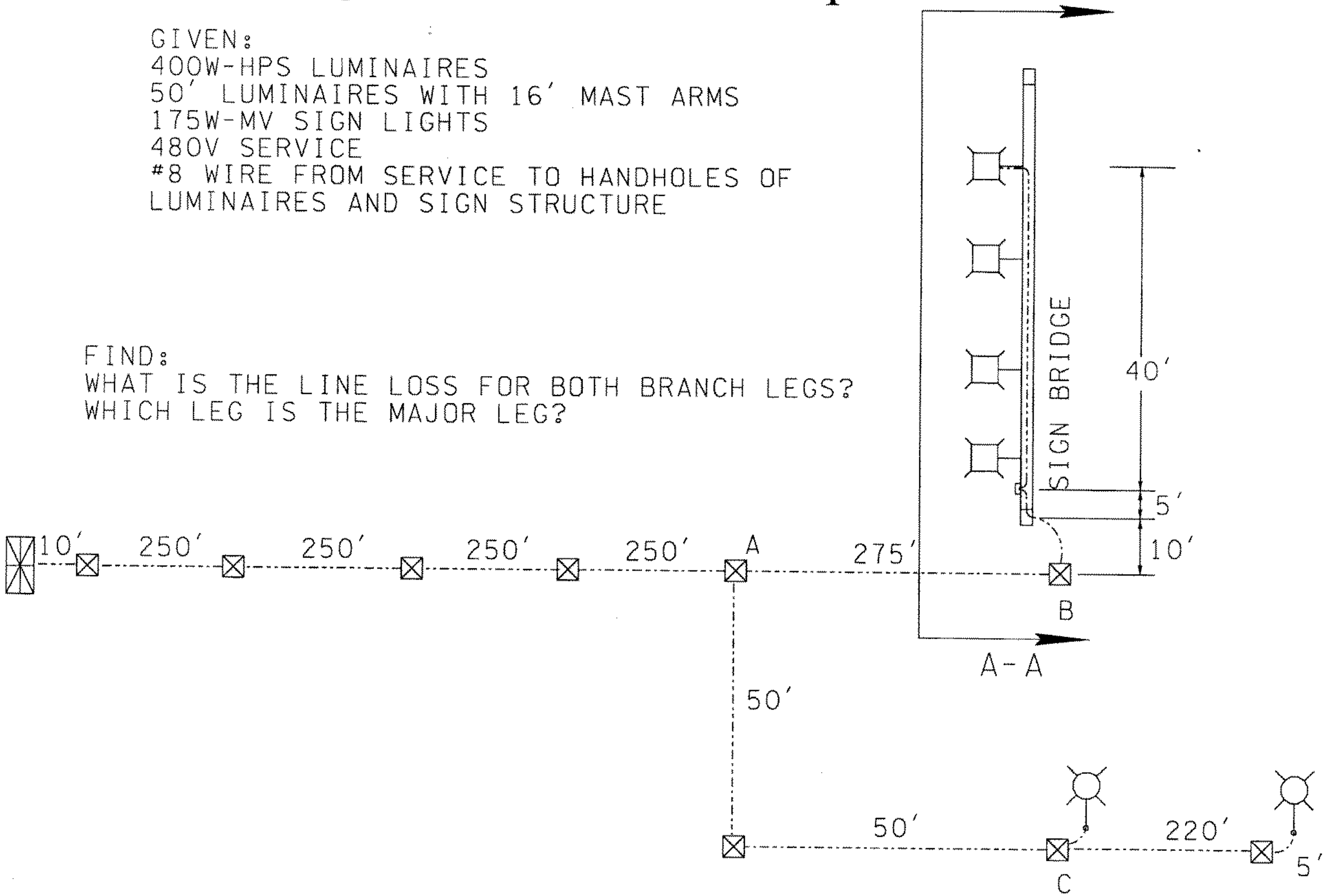
3.038361/120=0.025320*100=2.5% Vd

2.5% < 5% - #8 wire is acceptable

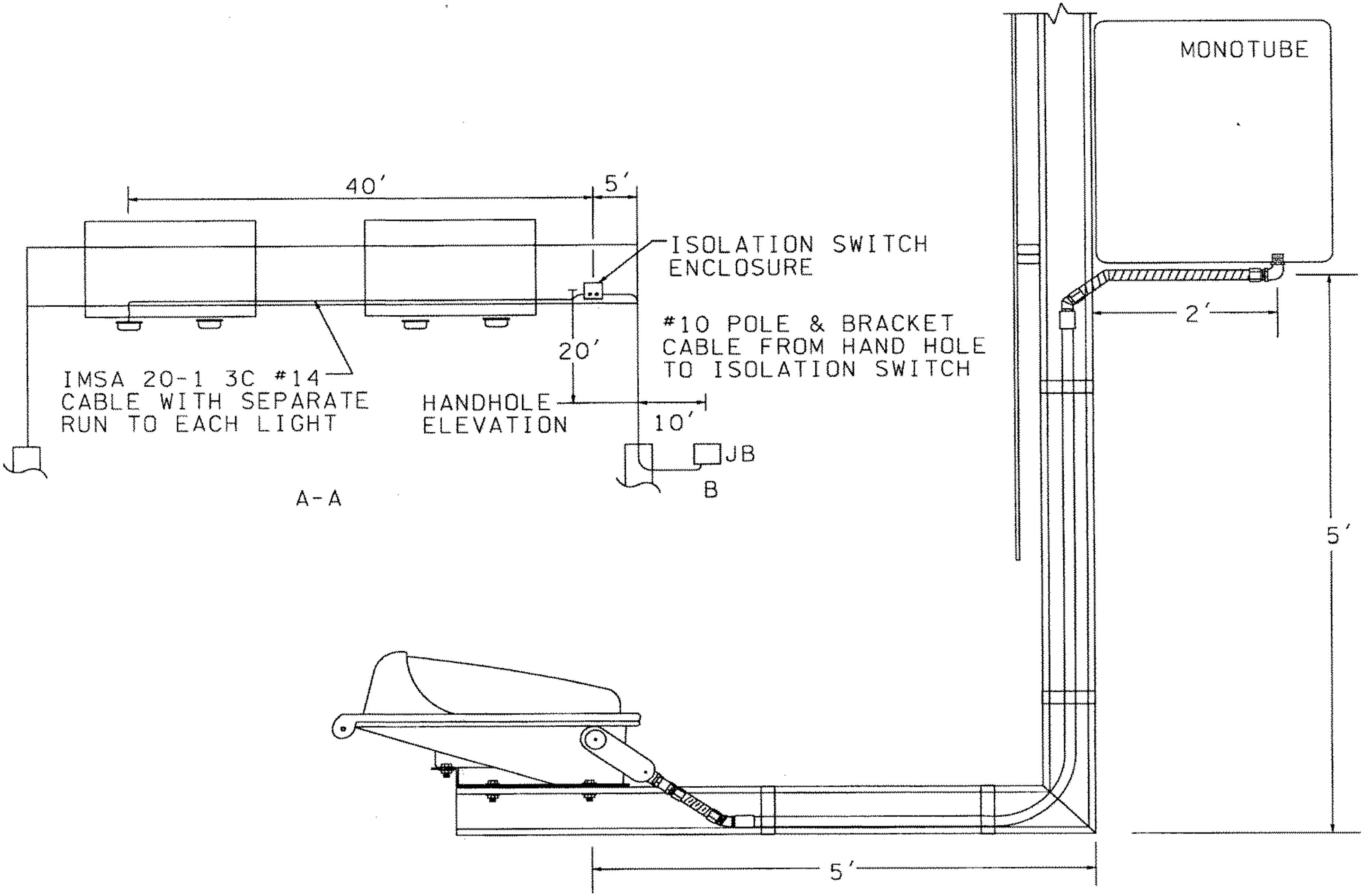
Signlighter & 480 Volt example

GIVEN:
400W-HPS LUMINAIRES
50′ LUMINAIRES WITH 16′ MAST ARMS
175W-MV SIGN LIGHTS
480V SERVICE
#8 WIRE FROM SERVICE TO HANDHOLES OF
LUMINAIRES AND SIGN STRUCTURE

FIND:
WHAT IS THE LINE LOSS FOR BOTH BRANCH LEGS?
WHICH LEG IS THE MAJOR LEG?



Signlighter @ 480 Volt example – cont.



Sign lighter & 480 Volt example – cont.

Calculating loads for this circuit

- 400 watt HPS luminaire at 480 volts = 1.1 amps
- 175 watt MV luminaire at 480 volts = 0.5 amps
- Total load for circuit = 2 (1.1) + 4 (0.5)
- Total Load = 4.2 amps

Voltage Drop for 2 Luminaire Circuit

Vd=2ALR

Wire out and Back

Resistance of #8 conductor

Total load on Segment

Total length of Segment

Service to A= (1060)

2(4.2)(5+10+10+250+10+250+10+250+10+250+5)(0.000809) =7.203336

A to C =2(2.2)(5+50+10+50+5=120)(0.000809) =0.427152

C to hand hole =2(1.1)(5+220+10+5+5=245)(0.000809) =0.436051

Hand hole to light =2(1.1)(62)(0.001290) =0.175956

8.242495

8.242495/480=0.017172*100=1.7% Vd

1.7% < 5% - #8 wire is acceptable

Resistance of #10 conductor

Voltage Drop for 4 Sign Light Circuit

Resistance of #8 conductor

Resistance of #10 conductor

Service to A= (1060)

	2(4.2)(5+10+10+250+10+250+10+250+10+250+5)(0.000809)	=7.203336
A to B	=2(2)(5+275+5=285)(0.000809)	=0.922260
B to hand hole	=2(2)(5+10+5=20)(0.000809)	=0.064720
Hand hole to ISO box	= 2(2)(20+5+2=27)(0.001290)	=0.139320
ISO box to out signlight	=2(0.5)(2+40+2+5+5+2=56)(0.003261)	=0.182616
		8.512252

8.512252/480=0.017734*100=1.8% Vd

1.8% < 5% - #8 wire is acceptable

Resistance of #14
IMSA conductor

Sign lighter & 480 Volt example – cont.

- The leg supplying the sign lights has a voltage drop of 1.8%.
- The leg supplying the luminaires has a voltage drop of 1.7%.
- The major leg is the one supplying the sign lights.

When laying out wire, keep this in mind:

- Keep all conductors from any one service in the junction boxes for that service. Do not **ever** combine conductors from one service with conductors from another service. **Do not share conduit or junction boxes between services.**
- Run 3 wires in the conduit when you are going cabinet to cabinet.
- The quick disconnects for the luminaire poles can only handle a #6 or #8 conductor, so make sure you bring one of these sizes into the luminaire and nothing larger.
- The splice kits for Wye splices or inline splices can only handle up to a #2 without going to a special, more expensive splice kit.
- The smallest size conductor we are allowed to use on an illumination circuit is a #8 (in the conduit) , except for the pole & bracket cable which is a #10 or the #14 3C IMSA cable from the isolation switch to the sign light luminaire. The largest you want to use is a #2 for ease of installation.
- As you move out from the service to the load end of the circuit, the size of the conductors should get smaller as you go. Do not go from a smaller conductor to a larger conductor.

Any Questions?

Electrical Design Training Class

Ampacity

presented by: Keith Calais

What is it?

- Ampacity is the current, in Amperes, that a conductor can carry continuously under the conditions of use without exceeding its temperature rating.

Why do we need to worry about it?

- If the conductors get too hot they will burn up and short out.

- As the conductor heats up the current carrying capacity goes down.

- If you overload the capacity of the conductors they will heat up and short out.

When do we calculate Ampacity?

- Ampacity should be considered every time you **add conductors to a conduit**.

- Every time you **modify an existing circuit**.

- On **all new designs** the ampacity should be checked.

How do we calculate it?

Ampacity is calculated by using this simple formula:

$$*I = \frac{TC - (TA + Delta\ TD)}{RDC(1+YC)RCA}$$

*All calculations must be checked and approved by a licensed electrical engineer.

Where:

TC=Conductor temperature in degrees Celsius

TA=Ambient temperature in degrees Celsius

DeltaTD=Dielectric loss temperature rise

RDC=dc resistance of conductor at temperature TC

YC= Component ac resistance resulting from skin effect of proximity effect

RCA=Effective thermal resistance between conductor and surrounding ambient

Or use this chart (2002 NEC 310.16):

(Not more than three current-carrying conductors in raceway, cable or earth(direct buried) based on ambient temperature of 86f)

Wire Size	Allowable Ampacities	Wire Size	Allowable Ampacities
14	20	1/0	150
12	25	2/0	175
10	35	3/0	200
8	50	4/0	230
6	65	250	255
4	85	300	285
3	100	350	310
2	115	400	335
1	130	500	380

Adjustment factors for more than three current-carrying conductors in a raceway or cable. ((2002 NEC 310.15(b)(2)(a))

Number of current carrying conductors	Percent of values in NEC Tables 310.16 thru 310.19
4-6	80
7-9	70
10-20	50
21-30	45
31-40	40
41 and above	35

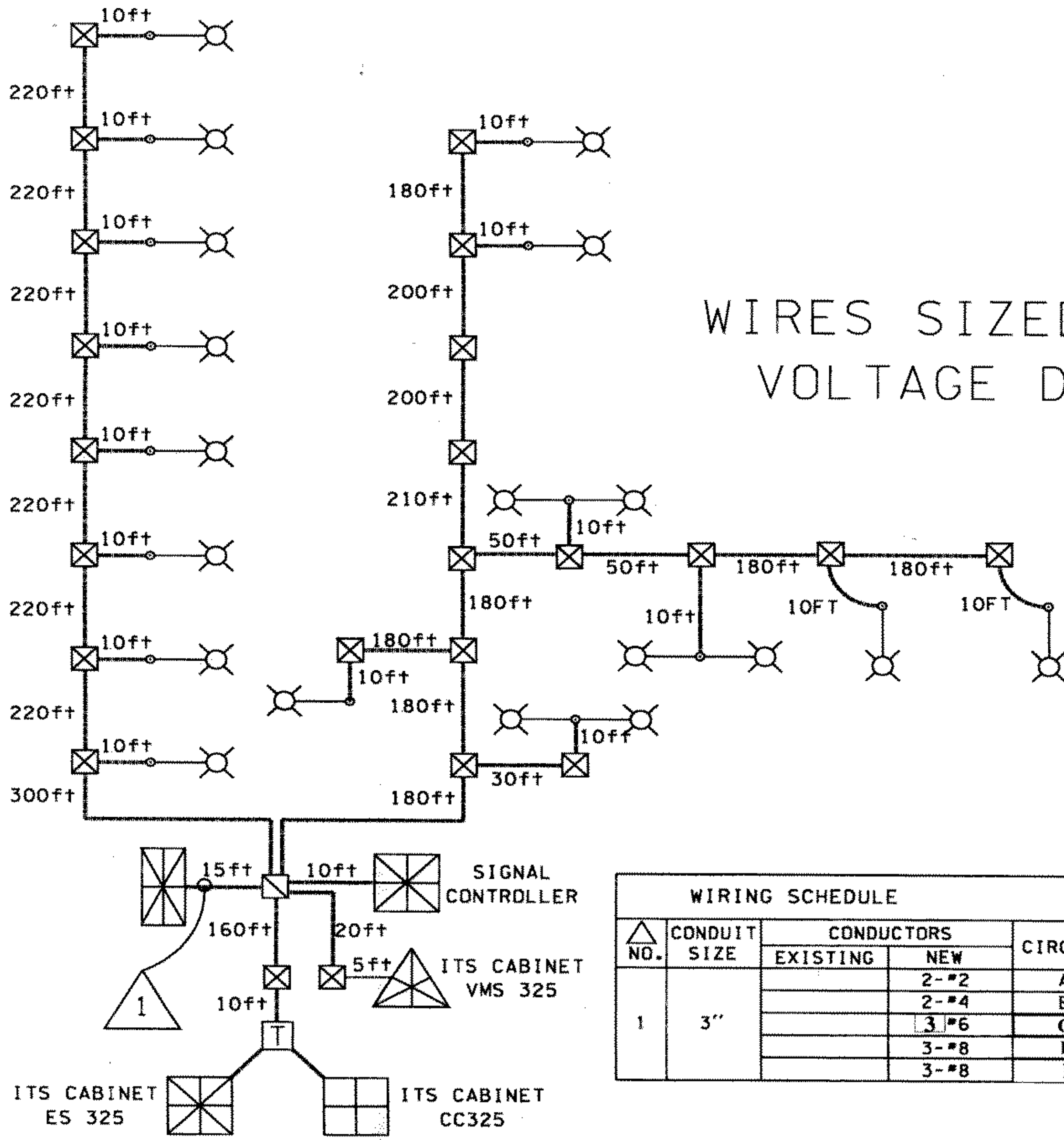
Potential Ampacity problems:

- The most common problem is at the conduit leaving the service.

- Large loads (usually ITS Transformers) sharing the same conduit as illumination circuits.

Check Ampacity of Wire

- **Given:** wire run #1 = one 3" conduit, containing Illumination circuit A with **2-#2**, Illumination circuit B with **2-#4**, ITS Transformer-ES 325 & CC325 circuit C with **3-#6**, ITS-VMS 325 circuit D with **3-#8** & Traffic Signal #1 circuit E with **3-#8** conductors for a total of 10 current carrying conductors. Note: These conductors are properly sized for allowable voltage drop. (they are the numbers we calculated in the Ampacity chapter.)



WIRES SIZED FOR VOLTAGE DROP

WIRING SCHEDULE					SERVICE NO.
NO.	CONDUIT SIZE	CONDUCTORS EXISTING	CONDUCTORS NEW	CIRCUIT	COMMENTS
1	3"		2-#2	A	LIGHTING SYSTEM A
			2-#4	B	LIGHTING SYSTEM B
			3-#6	C	ITS-ES 325 & CC 325
			3-#8	D	ITS-VMS 325
			3-#8	E	TRAFFIC SIGNAL

Check Ampacity of Wire - Continued

- **Illumination Circuit A load = 16.8 amps**

  Reduce ampacity by 50%.

  #2 wire ampacity = 115 amps x 0.5 = 57.5 amps.

  16.8 amps < 57.5 amps. **OK**

Check Ampacity of Wire - Continued

- **<u>Illumination Circuit B load</u> = 23.1 amps**

  Reduce ampacity by 50%.

  <u>#4 wire</u> ampacity = 85 amps x 0.5 = 42.5 amps.

  <u>23.1 amps < 42.5 amps.</u> **OK**

Check Ampacity of Wire - Continued

- **<u>ITS-ES 325 & CC 325-Circuit C load</u> = 31.25 amps**

  Reduce ampacity by 50%.

  #6 wire ampacity = 65 amps x 0.5 = 32.5 amps.

  31.25 amps < 32.5 amps. **OK.**

Check Ampacity of Wire - Continued

- **<u>ITS-VMS 325-Circuit D load</u> = 31.5 amps**

  Reduce ampacity by 50%.

  <u>#8 wire</u> ampacity = 50 amps x 0.5 = 25 amps.

  <u>31. 5 amps > 25 amps.</u> NOT OK.

  <u>#6 wire</u> ampacity = 65 amps x 0.5 = 32.5 amps.

  <u>31.5 amps < 32.5 amps.</u> **OK.**

Check Ampacity of Wire - Continued

- **<u>Signal - Circuit E load</u> = 41.73 amps**

  Reduce ampacity by 50%

<u>#8 wire</u> ampacity = 50 amps x 0.5 = 25 amps.

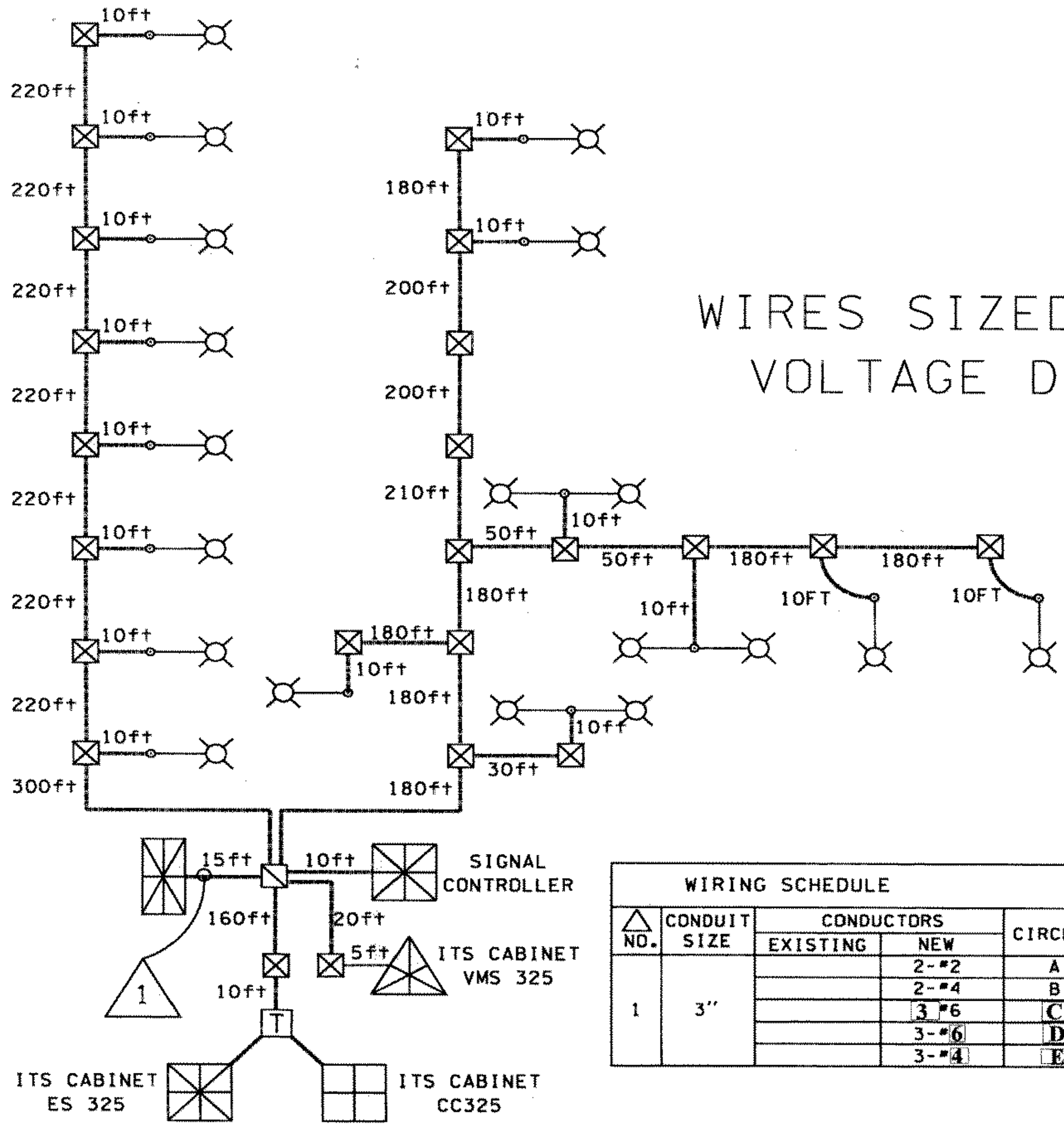
<u>41.73 amps > 25 amps.</u> **NOT OK.**

<u>#6 wire</u> ampacity = 65 amps x 0.5 = 32.5 amps.

<u>41.73 > 32.5 amps.</u> **NOT OK.**

<u>#4 wire</u> ampacity 85 amps x 0.5= 42.5 amps.

<u>41.73 < 42.5 amps.</u> **OK**



WIRES SIZED FOR VOLTAGE DROP

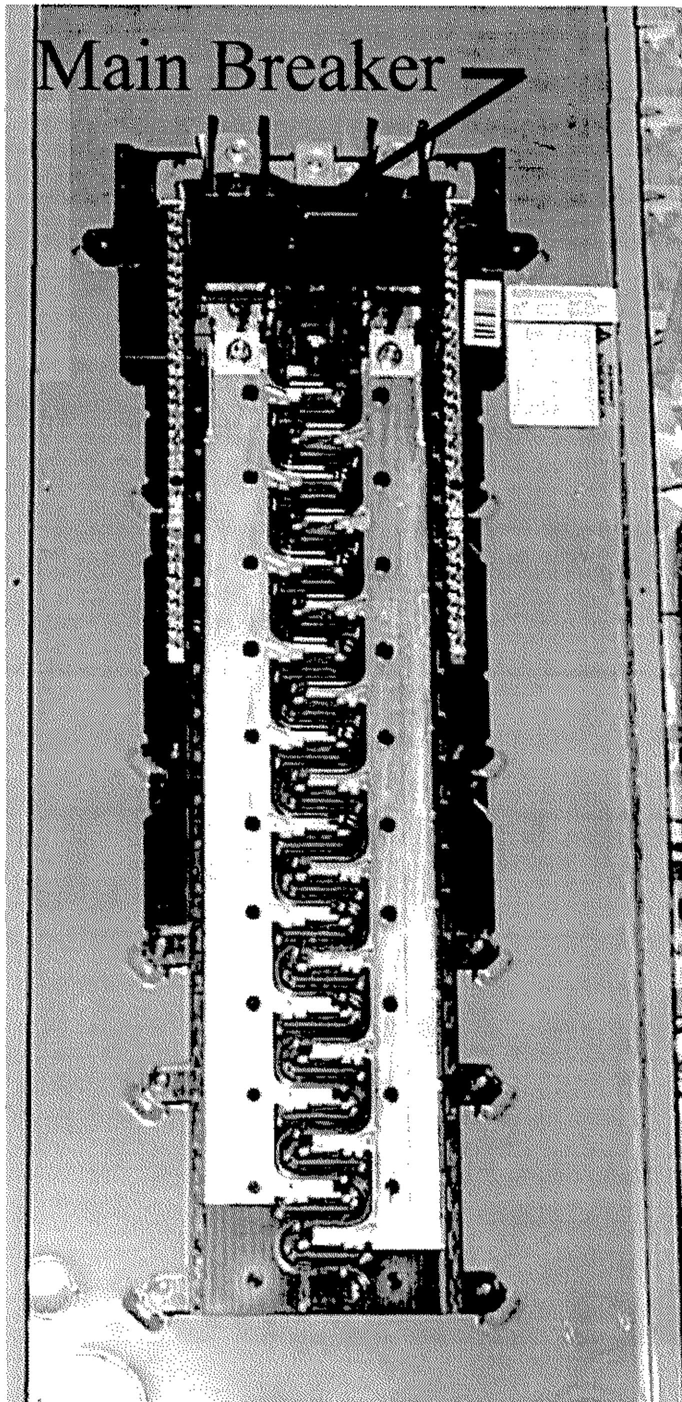
WIRING SCHEDULE					SERVICE NO.
NO.	CONDUIT SIZE	CONDUCTORS EXISTING	CONDUCTORS NEW	CIRCUIT	COMMENTS
1	3"		2-#2	A	LIGHTING SYSTEM A
			2-#4	B	LIGHTING SYSTEM B
			3-#6	C	ITS-ES 325 & CC 325
			3-#6	D	ITS-VMS 325
			3-#4	E	TRAFFIC SIGNAL

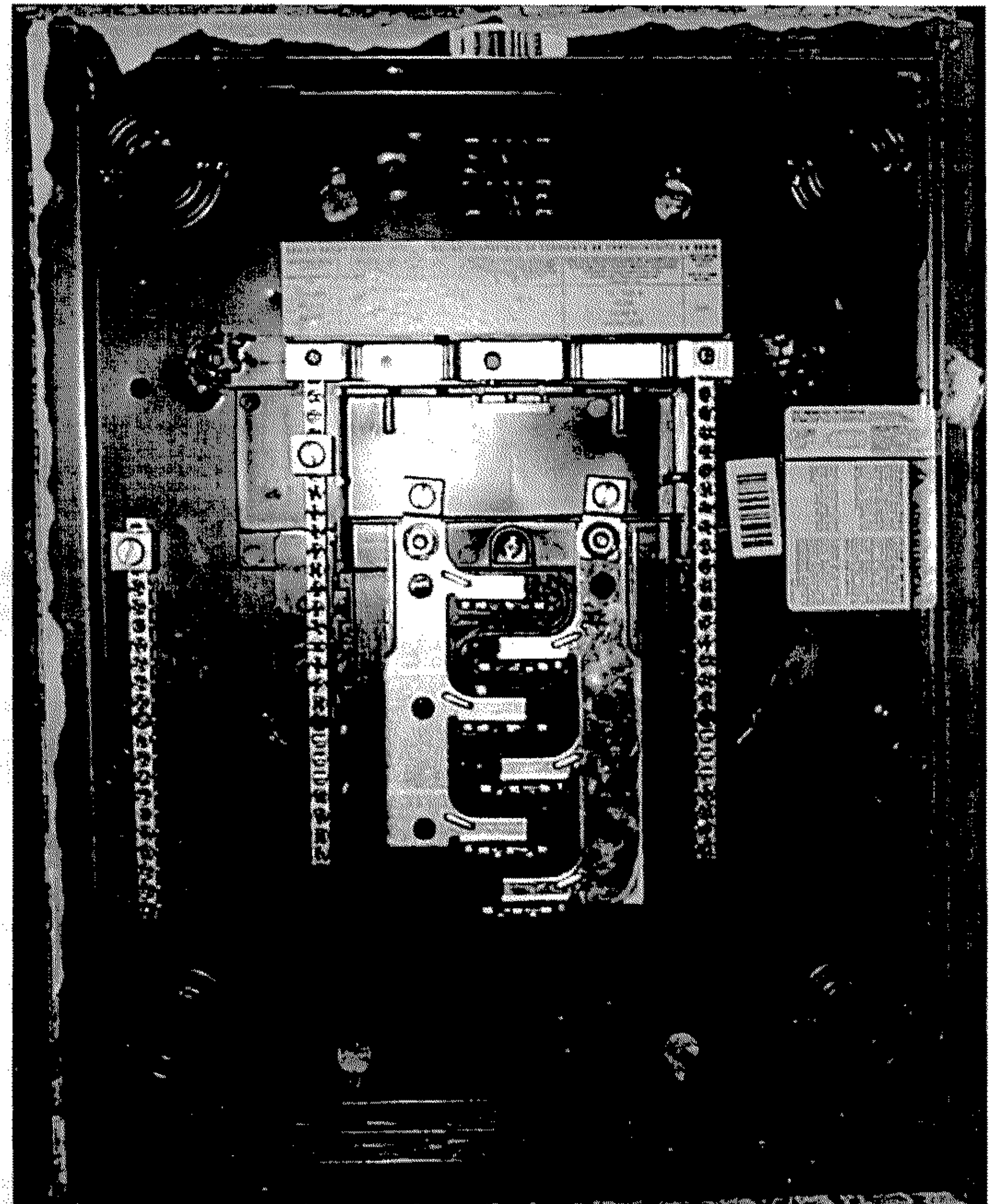
Electrical Design Training Class

Service Cabinet & Transformer Breaker sizing WSDOT

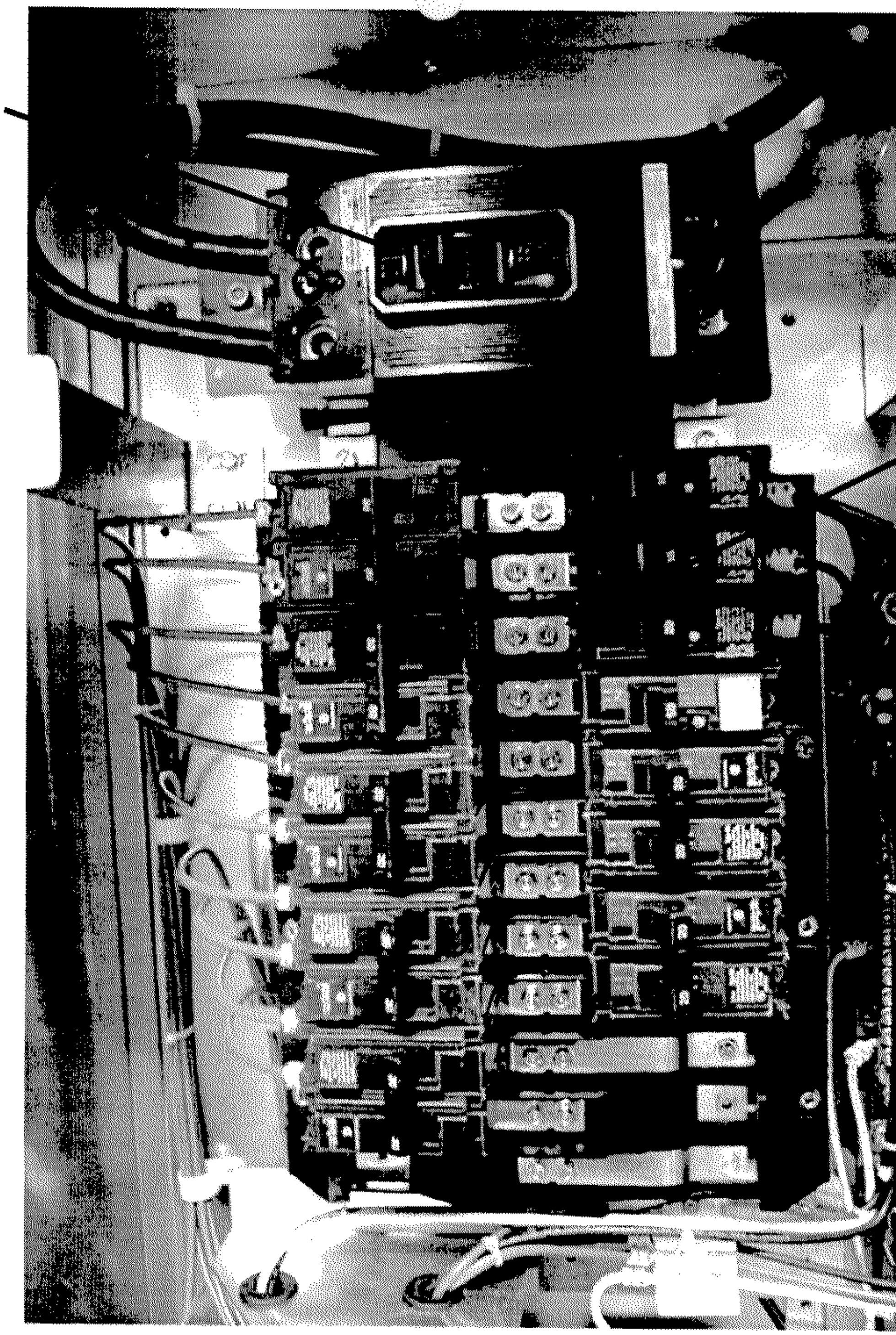
Fall / Winter 2004

Presented by: Keith Calais


Main Breaker

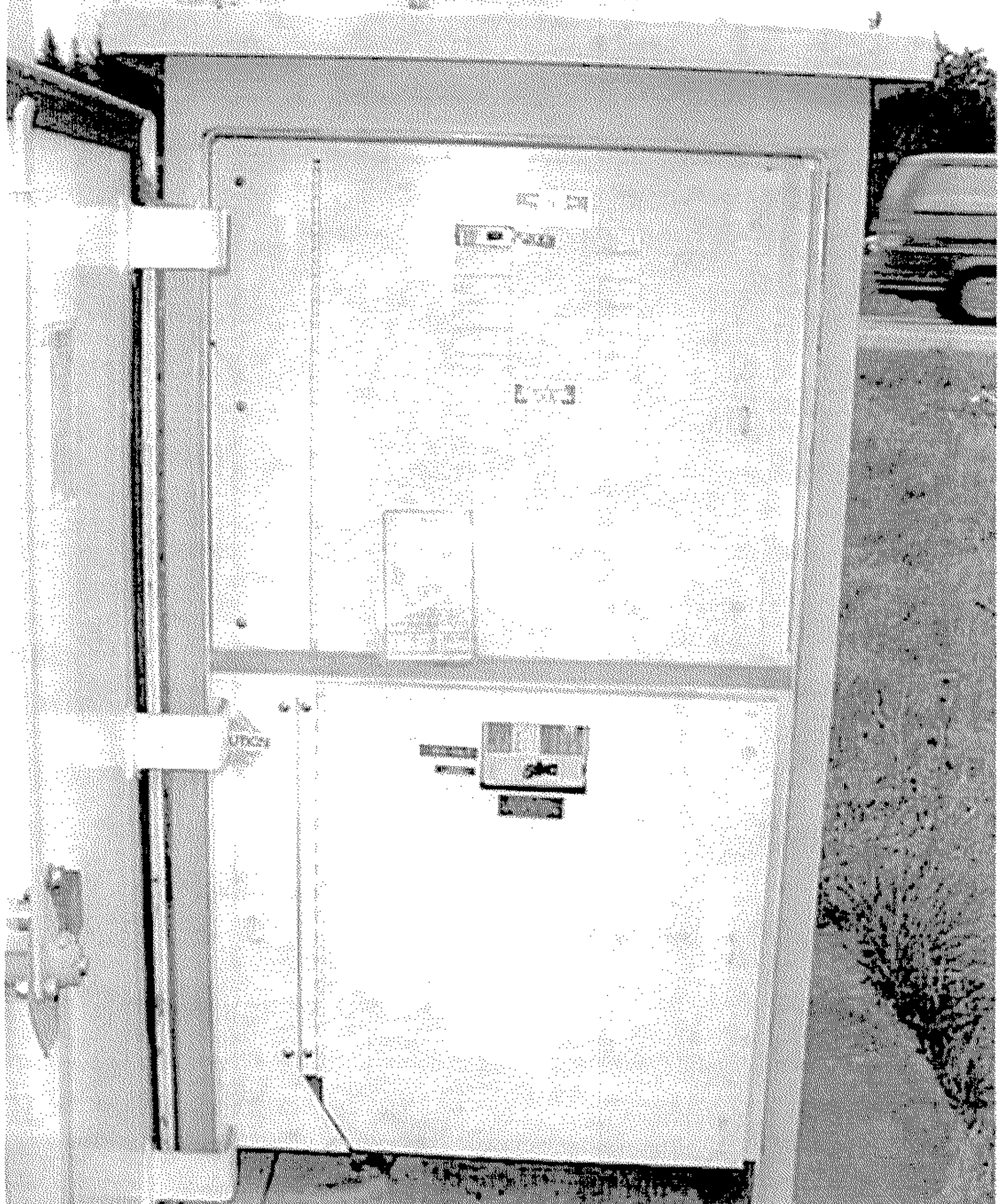


Main Breaker

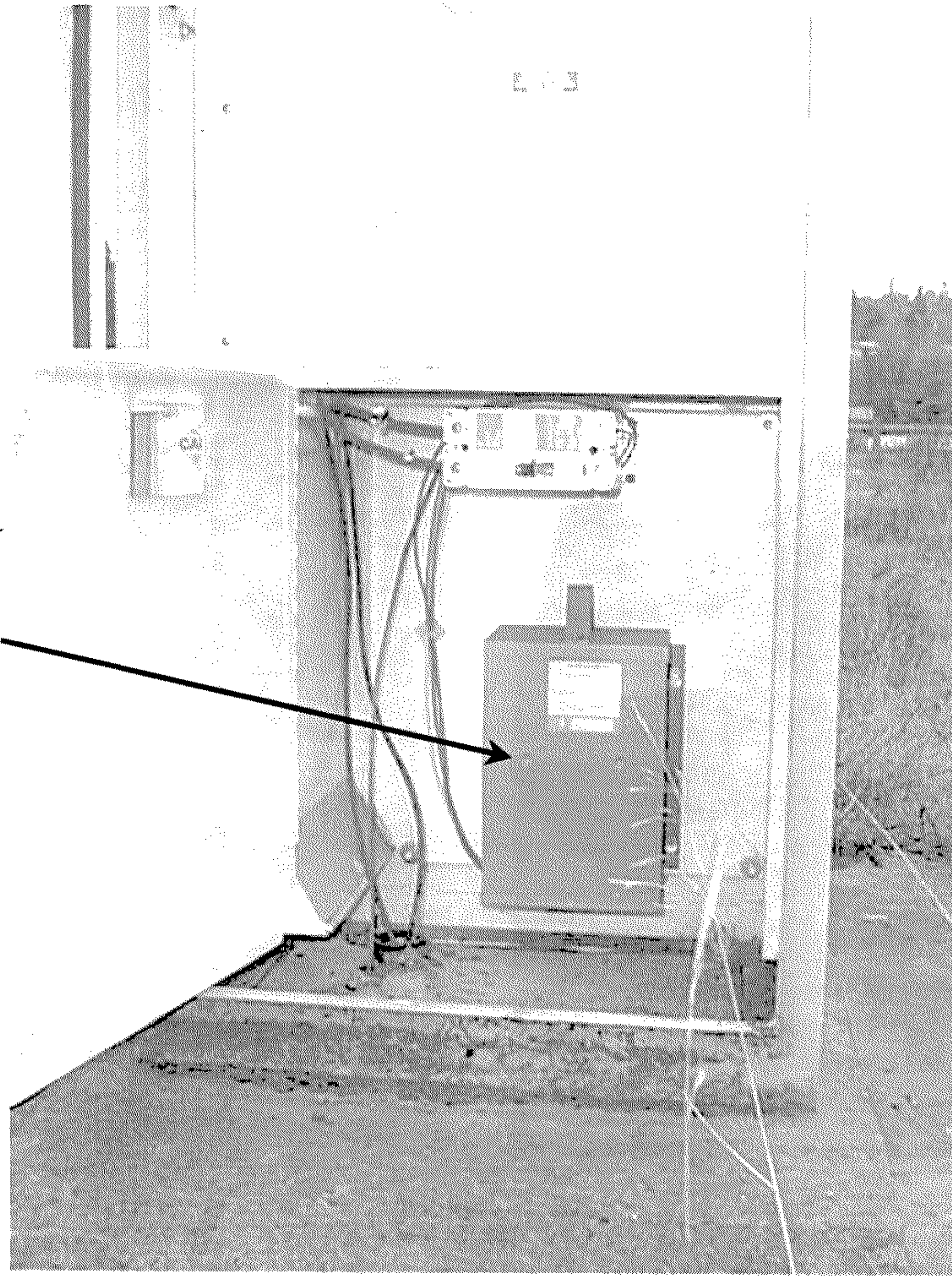


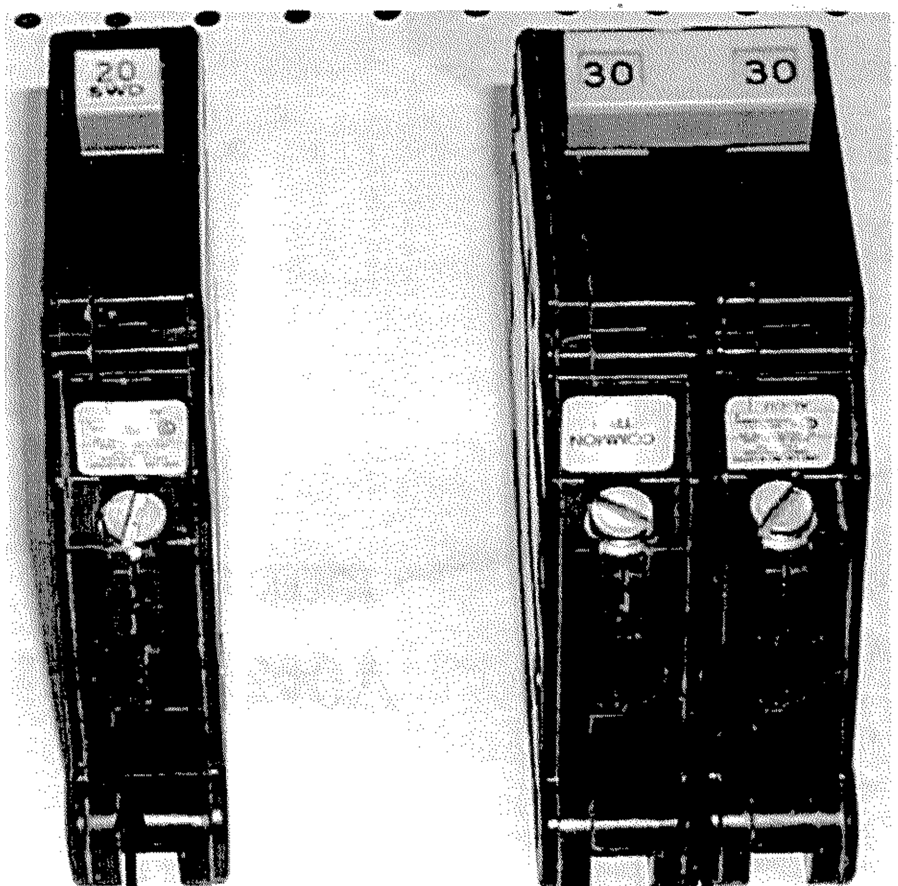
24 circuit
panel board

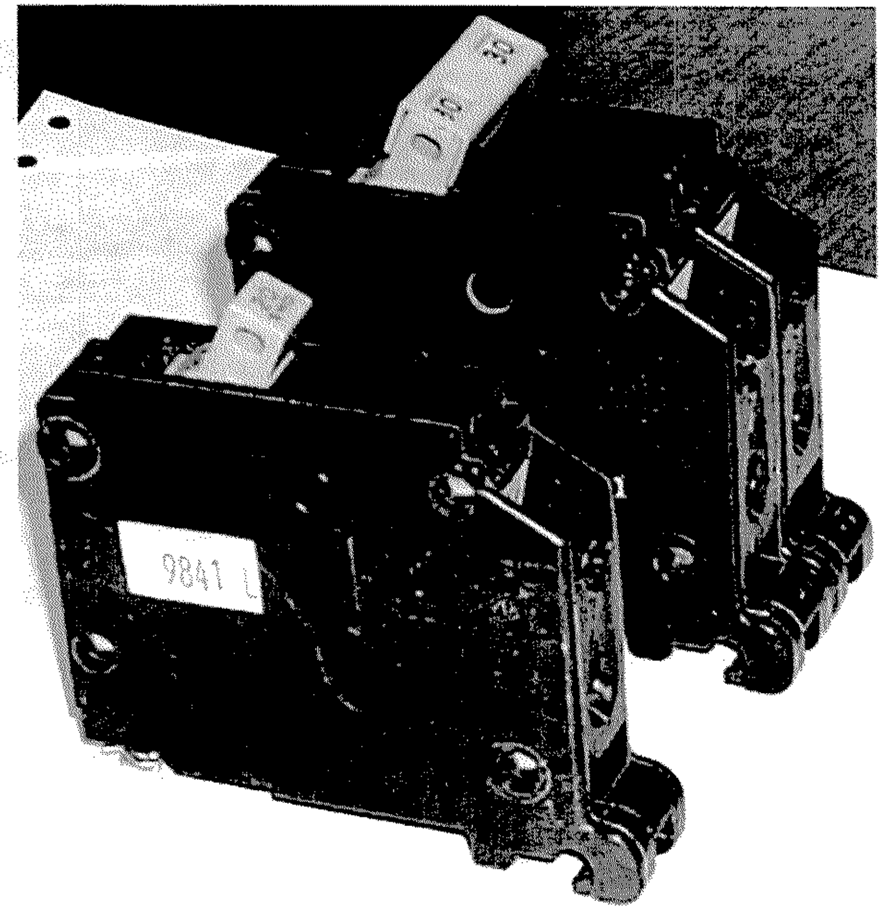
120V / 240V Transformer Cabinet



120V / 240V
Transformer



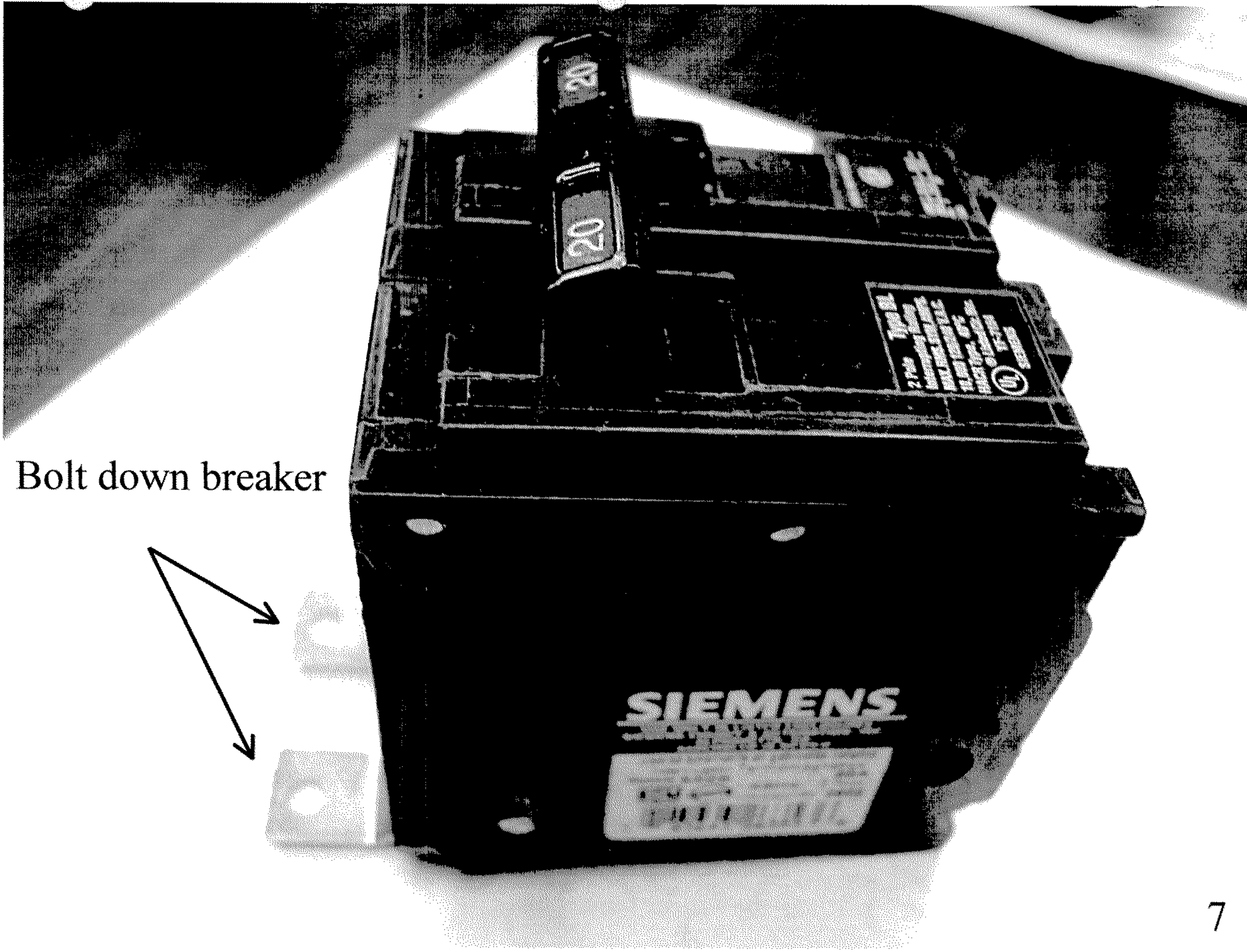




Double pole, single throw

Single pole, single throw

Bolt down breaker



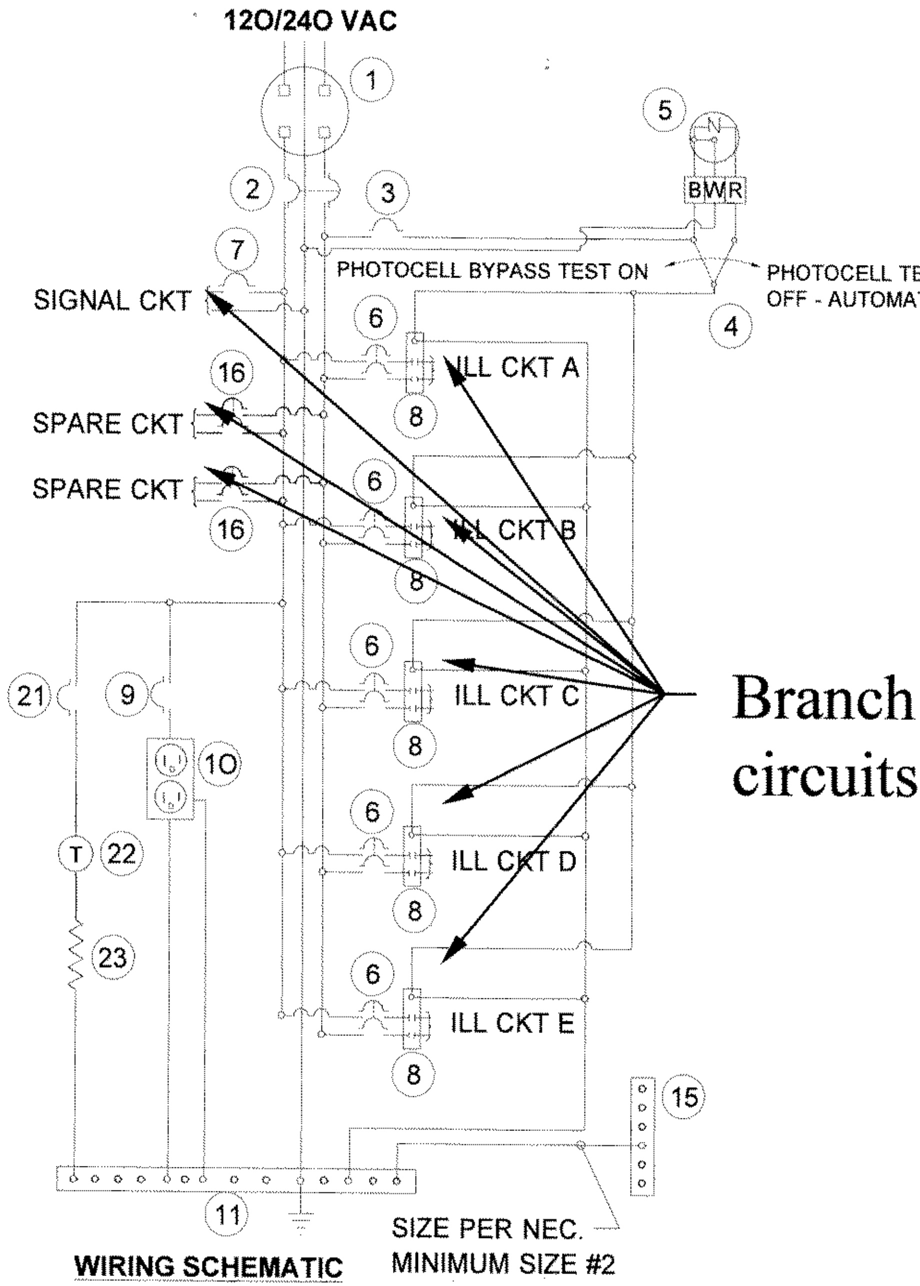
Definitions

- Circuit breaker - A device designed to open & close by nonautomatic means & to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating. (NEC 2002 - Article 100)

- Standard ampere ratings for fuses & inverse time circuit breakers shall be considered 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250, 300…,… (NEC 2002 - Article 240.6)

- Branch Circuit - The circuit conductors between the final overcurrent device protecting the circuit and the outlet(s). (NEC 2002 - Article 100)

- Continuous Load – A load where the maximum current is expected to continue for 3 hours or more. (NEC 2002 - Article 100)

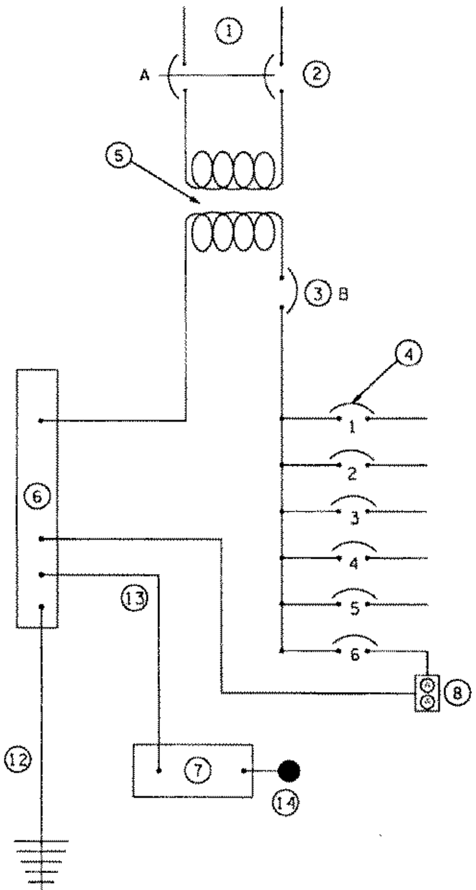


WIRING SCHEMATIC

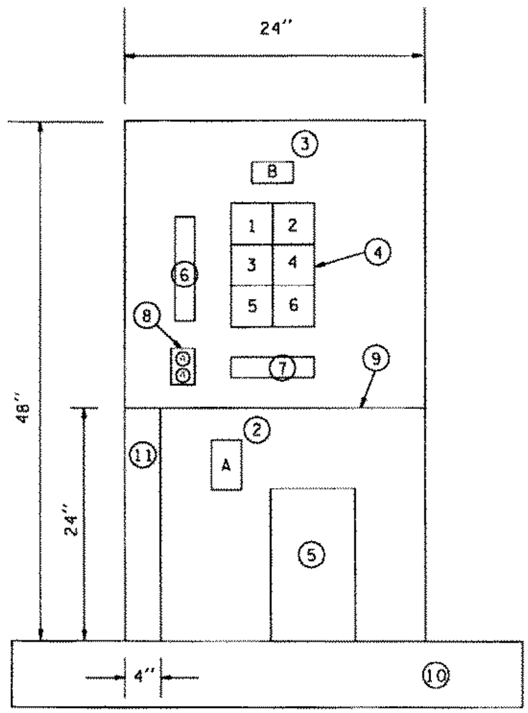
KEY

1. METER BASE PER SERVING UTILITY REQUIREMENTS. AS A MINIMUM, THE METER BASE SHALL BE SAFETY SOCKET BOX WITH FACTORY INSTALLED TEST BYPASS FACILITY THAT MEETS THE REQUIREMENTS OF EUSERC DRAWING 305.
2. MAIN BREAKER (SEE BREAKER SCHEDULE)
3. PHOTOCELL BREAKER (SPST 15 AMP - 120/240 VOLT)
4. TEST SWITCH (SPDT SNAP ACTION, POSITIVE CLOSE 15 AMP - 120/277 VOLT "T" RATED)
5. PHOTO ELECTRIC CONTROL, STD. SPEC. 9 - 29.11(2)
6. BRANCH BREAKER (SEE BREAKER SCHEDULE)
7. SIGNAL BREAKER (SEE BREAKER SCHEDULE)
8. CONTACTOR (SEE BREAKER SCHEDULE)
9. RECEPTACLE BREAKER (SPST 20 AMP - 120/240 VOLT)
10. RECEPTACLE, GROUNDED (GFCI 20 AMP - 125 VOLT)
11. NEUTRAL BUSS, 14 LUG COPPER
12. PHOTOCELL ENCLOSURE - ENCLOSURE TO BE FABRICATED FROM 5/8" EXPANDED STEEL MESH WITH WELDED SEAMS AND MOUNTING FLANGES. HOT DIP GALVANIZED AFTER FABRICATION. TYPE 5052 - H32 ALUMINUM WITH 5/8" x 5/8" OPENINGS EQUIVALENT TO 5/8" EXPANDED STEEL MESH MAY BE USED AS ALTERNATIVE MATERIAL. SEE PHOTOCELL ENCLOSURE MOUNTING DETAILS. SPECIAL DESIGN SERVICE CABINET TYPE B MODIFIED.
13. HINGED FRONT FACING DOOR WITH 4" x 4" MIN POLISHED WIRE GLASS WINDOW.
14. HINGED DEAD FRONT WITH 1/4 TURN FASTENERS OR SLIDE LATCH
15. CABINET MAIN BONDING JUMPER. BUSS SHALL BE 4 LUG TINNED COPPER. SEE CABINET MAIN BONDING JUMPER DETAIL ON SPECIAL DESIGN SERVICE CABINET TYPE B MODIFIED.
16. SPARE BRANCH BREAKER (DPST 20AMP- 120/240 VOLT)
17. METAL WIRING DIAGRAM HOLDER
18. REMOVABLE EQUIPMENT MOUNTING PAN
19. 6" x 6" MIN UNDERGROUND FEED - SERVICE WIREWAY (LEFT REAR CORNER)
20. SCREENED VENTS, 2 REQUIRED, 1 EACH SIDE, LOUVERED PLATES
21. HEATER BREAKER (SPST 15 AMP - 120/240 VOLT)
22. THERMOSTAT, 40°F CLOSURE - 3 DIFFERENTIAL
23. STRIP HEATER (100 WATT NOMINAL) , WITH TERMINAL STRIP COVER

ITS Transformer Detail sheet



CIRCUIT DIAGRAM



INTERIOR DETAILS
(WITH DEAD FRONTS REMOVED)

120/240V TRANSFORMER DETAIL

KEY

1. PRIMARY POWER.
2. MAIN BREAKER.
3. SECONDARY MAIN BREAKER.
4. SECONDARY BRANCH BREAKERS. 6 CIRCUIT PANEL BOARD MINIMUM SIZE WITH SEPERATE MAIN BREAKER.
5. TRANSFORMER.
6. NEUTRAL BUSS.
7. GROUND BUSS.
8. RECEPTACLE GROUNDED (GFCI 20 AMP, 125 VOLT).
9. PERMANENTLY AFFIXED COMPARTMENT SEPARATOR.
10. SEE FOUNDATION DETAILS, SHEET ITDXX AND ITDXX.
11. ENCLOSED WIREWAY FOR 120V CIRCUITS.
12. GROUNDING ELECTRODE.
13. MAIN BONDING JUMBER.
14. CABINET BONDING JUMPER.

GENERAL NOTES

1. 3 KVA, 5KVA, 10 KVA TRANSFORMER CABINET SHALL BE 48" HIGH X 24" WIDE X 20" DEEP.
2. THE SECONDARY BRANCH BREAKERS SHALL BE BOLT IN TYPE, MOUNTED ON COPPER BUSSWORK RATED AT 100 AMPS.
3. ALL CIRCUIT BREAKERS INSTALLED SHALL BE PERMANENTLY MARKED WITH APPLICABLE CIRCUIT NAME.
4. THE DEAD FRONT SHALL BE FABRICATED IN TWO PARTS, ONE FOR EACH COMPARTMENT.
5. THE DOOR HINGE SHALL BE MOUNTED ON THE LEFT SIDE.
6. BOLT PATTERN IS PROVIDED BY CABINET MANUFACTURER. BOLTS SHALL BE ⅝" DIA AND EXTEND 1½" ABOVE CONCRETE PAD.
7. SEE SECTION 9-29.24 OF THE STANDARD SPECIFICATIONS FOR ADDITIONAL REQUIREMENT.
8. TRANSFORMER VOLTAGE AND KVA REQUIREMENTS ARE AS SHOWN IN THE PLANS AND SPECIAL PROVISIONS.
9. SEE ITS BREAKER SCHEDULE FOR SIZE AND QUANTITY OF BREAKERS.
10. THE 25KVA TRANSFORMER CABINET SIZE SHALL BE 60" X 32" X 30" WITH DOORS ON BOTH SIDE AND MANUAL TRANSFORMER SWITCH ON BACK SIDE.

Sizing Branch Breakers

- Illumination Branch breakers are to be sized to carry 140 percent minimum of the total computed load.
- Non-illumination Branch breakers are to be sized to carry 125 percent continuous load plus 100% of the noncontinuous load. (NEC 2002 Article 210.20(A) Overcurrent protection - Continuous & Noncontinuous loads)
- Illumination loads should be calculated using the line-operating amps out of the supplier catalog. If the line-operating amps out of the supplier catalog is not used then loads should be computed in accordance with the lamp load factors as discussed in Design Manual Chapter 840. (Design Manual May 2000. figure 840-9a, or Traffic Manual July 1993. Page 4-15, figure 4-6)

Sizing Illumination Contactors

- Illumination Contactors must be equal to or larger than the Amperage rating for the branch breaker controlling that circuit.

- Illumination Contactors come in three sizes, 30, 60, and 100 Amps. (Per the NEC, lighting circuits can not be bigger than 50 amps) (NEC 2002 210.23(D) Branch Circuits Larger than 50 Amperes)

Sizing Lighting Branch Breaker Circuit A

Illumination Circuit A load

8 each - 400 watt, HPS Luminaires, 240 VAC, 2.1 Amps per luminaire

8 x 2.1 amps = 16.8 Amps

Illumination Circuit A Breaker

16.8 amps continuous load x 140% factor = 23.52 amps

Use 30 amp circuit breaker. (NEC Article 210-20 (a) Overcurrent protection - Continuous & Noncontinuous loads)

Use 30 Amp contactor

Sizing Lighting Branch Breaker Circuit B

Illumination Circuit B load

11 each - 400 watt, HPS Luminaires, 240 VAC, 2.1 amps per luminaire

11 x 2.1 amps = 23.1 amps

Illumination Circuit B Breaker

23.1 amps continuous load x 140% factor = 32.34 amps

Use 40 amp circuit breaker. (NEC Article 210-20 (a) Overcurrent protection - Continuous & Noncontinuous loads)

Use 60 Amp contactor.

Sizing ITS Branch Breaker Circuit C

ITS Cabinets ES326/CC325 - Circuit C load

240 VAC, 7500 watts total load

7500 watts continuous load/240 volts=31.25 amps

ITS Cabinets ES326/CC325 – Circuit C Breaker

31.25 amps continuous load x 125% factor=39.0625 amps

Use 40 amp circuit breaker. (NEC Article 210-20 (a) Overcurrent protection - Continuous & Noncontinuous loads)

This completes the sizing of the circuit breaker for the ITS Branch Breaker Circuit C in the Service Cabinet. Go to slide 21 For continuation of sizing of branch breakers within the service cabinet. The next 5 slides detail sizing the breakers within the transformer cabinet and then within the Camera Cabinet (CC) and the ITS Cabinet Data Station(ES)

Circuit C1
Camera Cabinet - CC325

- Camera Cabinet (CC) - 324W + 1800W(GFCI's) = 2124W.
- Camera Cabinet Circuit C1 Load
- Controller-120 VAC, 324 watts continuous load.
- Camera Cabinet – Outlet 120 VAC, 1800watts non-continuous load.
- 1800watts non-continuous load / 120 VAC = 15.0 amps
- 324 watts continuous load / 120 VAC = 2.70 amps
- Camera Cabinet Circuit C1 Breaker
- Continuous load - 2.70 amps x 125% = 3.375 amps
- Non-continuous loads – 15.0 amps
- 3.375 amps Continuous + 15.0 amps Non-continuous = 18.375 amps
- Use 20 amp circuit breaker. (NEC Article 210-20 (a) Overcurrent protection - Continuous & Noncontinuous loads)

Circuit C2
ITS Cabinet Data Station(ES) 325

- Data Station (CC) - 252W + 1800W(GFCI's) = 2052W.
- Data Station Circuit C2 Load
- Controller-120 VAC, 252 watts continuous load.
- Data Station – Outlet 120 VAC, 1800watts non-continuous load.
- 1800watts non-continuous load / 120 VAC = 15.0 amps
- 252 watts continuous load / 120 VAC = 2.1 amps
- Data Station Circuit C2 Breaker
- Continuous load - 2.1 amps x 125% = 2.625 amps
- Non-continuous loads – 15.0 amps
- 2.625 amps Continuous + 15.0 amps Non-continuous = 17.625 amps
- Use 20 amp circuit breaker. (NEC Article 210-20 (a) Overcurrent protection - Continuous & Noncontinuous loads)

Circuit C3
Transformer Outlet

Outlet Circuit C3 load

120 VAC, 1800 watts

1800 watts continuous load / 120 VAC = 15.0 amps

Outlet – Circuit C3 Breaker

15.0 amps continuous load x 125% = 18.75 amps

Use 20 amp circuit breaker. (NEC Article 210-20 (a) Overcurrent protection - Continuous & Noncontinuous loads)

Secondary Main Breaker Load -Transformer panel

Circuit, Voltage	Noncont. Load		Cont. Load		Factor	A	N
C1-CC325, 120 VAC	15.0 amps	+	2.700 Amps	x	125%	18.375	
C2-ES325, 120 VAC	15.0 amps	+	2.100 Amps	x	125%	17.625	
C3-Outlet, 120 VAC	15.0 amps					15.00	
TOTAL SIZED LOAD:						50.475	

- Size the secondary main breaker inside the transformer for total load that can be drawn from the transformer.
- 7.5 kVA-120/240volt transformer is 7,500watts/120volts=62.50 amps.
- Use a 60 amp secondary main breaker to protect the secondary windings in the transformer.
- Note: Remember that this 60 amp breaker is mounted on a 100 amp rated, 6 circuit panel board.

Main Breaker in Transformer Circuit C

Circuit C load

240 VAC, 7500 watts total load

7500 watts continuous load/240 volts=31.25 amps

Transformer Main Breaker Circuit C

31.25 amps continuous load x 125% factor=39.0625 amps

Use 40 amp circuit breaker. (NEC Article 210-20 (a) Overcurrent protection - Continuous & Noncontinuous loads)

Sizing ITS Branch Breaker Circuit D

ITS Cabinet VMS 326 - Circuit D load

120 VAC, 3780 watts total load

1980 watts continuous load/120 volts=16.5 amps

1800 watts noncontinuous load/120 volts=15.0 amps

ITS Cabinet VMS 326 – Circuit D Breaker

16.5 amps continuous load x 125% factor=20.625 amps

15.0 noncontinuous load

20.625 amps + 15.0 amps=35.625 amps

Use 40 amp circuit breaker. (NEC Article 210-20 (a) Overcurrent protection - Continuous & Noncontinuous loads)

Sizing Traffic Signal Branch Breaker Circuit E

Traffic Signal Cabinet Circuit E load

120 VAC, 5008 watts total load

3208 watts continuous load/120 volts=26.73 amps

1800 watts noncontinuous load/120 volts=15.0 amps

Traffic Signal Cabinet – Circuit E Breaker

26.73 amps continuous load x 125% factor=33.4125 amps

15.0 noncontinuous load

33.4125 amps + 15.0 amps=48.4125 amps

Use 50 amp circuit breaker. (NEC Article 210-20 (a) Overcurrent protection - Continuous & Noncontinuous loads)

Sizing Outlet Branch Breaker Circuit I

Outlet Circuit I load

120 VAC, 1800 watts

1800 watts continuous load / 120 VAC = 15.0 amps

Outlet – Circuit I Breaker

15.0 amps continuous load x 125% = 18.75 amps

Use 20 amp circuit breaker. (NEC Article 210-20 (a) Overcurrent protection - Continuous & Noncontinuous loads)

Sizing Heat Strip Branch Breaker Circuit J

Heat strip Circuit J load

120 VAC, 100 watts per strip

100 watts continuous load / 120 VAC = 0.83 amps

Heat strip – Circuit J Breaker

0.83 amps continuous load x 125% = 1.04 amps

Use 15 amp circuit breaker. (NEC Article 210-20 (a) Overcurrent protection - Continuous & Noncontinuous loads

Sizing Photocell Branch Breaker Circuit K

Photocell Circuit K load

120 VAC, 1.1 watts

1.1 watts (photocell model SST-IES from Tyco Electronics Area Lighting)
continuous load / 120 VAC = 0.009 amps

Photocell – Circuit K Breaker

0.009 amps continuous load x 125% = 0.011 amps

Use 15 amp circuit breaker. (NEC Article 210-20 (a) Overcurrent protection - Continuous & Noncontinuous loads

Verify Breaker protects Conductors

- CKT A
- #2 reduced by 50% Ampacity = 115A x 0.5 = 57.5 Amps
- Breaker Size = 30 Amps
- 57.5 Amps Allowable through conductor > 30 Amp breaker
- #2 conductor protected by 30 Amp Breaker is **OK**
- CKT B
- #4 reduced by 50% Ampacity = 85A x 0.5 = 42.5 Amps
- Breaker size = 40 Amps
- 42.5 Amps Allowable through conductor > 40 Amp breaker
- #4 conductor protected by 40 Amp Breaker is **OK**

Verify Breaker protects Conductors-cont.

- CKT C
- #6 reduced by 50% Ampacity = 65A x 0.5 = 32.5 Amps
- Breaker size = 40 Amps
- 32.5 Amps Allowable through conductor < 40 Amp breaker
- #6 conductor protected by 40 Amp Breaker is **NOT OK**
- CKT C
- #4 reduced by 50% Ampacity = 85A x 0.5 = 42.5 Amps
- Breaker size = 40 Amps
- 42.5 Amps Allowable through conductor > 40 Amp breaker
- #4 conductor protected by 40 Amp Breaker is **OK**

Verify Breaker protects Conductors-cont.

- CKT D
- #6 reduced by 50% Ampacity = 65A x 0.5 = 32.5 Amps
- Breaker size = 40 Amps
- 32.5 Amps Allowable through conductor < 40 Amp breaker
- #6 conductor protected by 40 Amp Breaker is **NOT OK**
- CKT D
- #4 reduced by 50% Ampacity = 85A x 0.5 = 42.5 Amps
- Breaker size = 40 Amps
- 42.5 Amps Allowable through conductor > 40 Amp breaker
- #4 conductor protected by 40 Amp Breaker is **OK**

Verify Breaker protects Conductors-cont.

- CKT E
- #4 reduced by 50% Ampacity = 85A x 0.5 = 42.5 Amps
- Breaker size = 50 Amps
- 42.5 Amps Allowable through conductor < 50 Amp breaker
- #4 conductor protected by 50 Amp Breaker is **NOT OK**
- CKT E
- #3 reduced by 50% Ampacity = 100A x 0.5 = 50.0 Amps
- Breaker size = 50 Amps
- 50.0 Amps Allowable through conductor = 50 Amp breaker
- #3 conductor protected by 50 Amp Breaker is **OK**

WIRING SCHEDULE				SERVICE NO.	
△ NO.	CONDUIT SIZE	CONDUCTORS		CIRCUIT	COMMENTS
		EXISTING	NEW		
1	3''		2-#2	A	ILLUMINATION
			2-#4	B	ILLUMINATION
			3-#4	C	ITS TRANSFORMER
			3-#4	D	VMS CABINET
			3-#3	E	SIGNAL CABINET

Service Cabinet Main Breaker Load

Circuit,Voltage	Noncont. Load		Cont. Load		Factor	A	N	B
A-Illumination A, 240 vac			16.80 Amps	x	140%	23.52		23.52
B-Illumination B, 240 vac			23.10 Amps	x	140%	32.34		32.34
C-ITS Transformer, 240 vac			31.25 Amps	x	125%	39.06		39.06
D-ITS Cabinet, 120 vac	15.0 amps	+	(16.50 Amps	x	125%)	35.63		------
E-Signal Controller, 120 vac,	15.0 amps	+	(26.73 Amps	x	125%)	------		48.41
I-Outlet, 120 vac	15.0 amps					15.00		------
J-Heat Strip, 120 vac			0.83 Amps	x	125%	1.04		------
K-Photocell, 120 vac			0.009 Amps	x	125%	------		0.011
TOTAL SIZED LOAD:						146.59*		143.34

* Size the main breaker for the buss with the largest load.

Sizing Main Breaker and Busswork

Size the main breaker for the buss with the largest load.

146.59 Amps x 133% (future capacity) = 194.96 Amps

Use 200 amp Main Breaker as minimum size to provide for future loads.

The Busswork in this example should be 200 Amp minimum. With the new Service Cabinets, specify 250 Amp Busswork in every cabinet. If the main breaker is larger than 200 Amps, the standard service cabinet details must be modified.

Size the feeder wires, the wires between the serving utility transformer and the main breaker, to handle the maximum busswork capacity.

Conductor Types and Sizes for 120/240V, 3-Wire, Single-Phase Dwelling Services and Feeders.

Copper	Aluminum or Copper-Clad Aluminum	Feeder Rating (Amperes)
4	2	100
3	1	110
2	1/0	125
1	2/0	150
1/0	3/0	175
2/0	4/0	200
3/0	250	225
4/0	300	250
250	350	300
350	500	350
400	600	400

NEC 2002 - Table 310.15(b)(6)

Sizing Feeder wires

- Per the previous chart, this service has a 200 Amp main breaker with 250 amp busswork. The feeder conductors should be 3 each - 4/0.

Allowable Ampacities of Insulated Conductors rated 0 through 2000 volts:
Not more than three current-carrying conductors in raceway, cable or earth(direct buried) based on ambient temperature of 86f. (2002 NEC 310.16)

For 240/480 volt service feeders use this chart

Wire Size	Allowable Ampacities	Wire Size	Allowable Ampacities
14	20	1/0	150
12	25	2/0	175
10	35	3/0	200
8	50	4/0	230
6	65	250	255
4	85	300	285
3	100	350	310
2	115	400	335
1	130	500	380

BREAKER SCHEDULE SUA 1

TYPE D SERVICE 120/240V

CIRCUIT	DESCRIPTION	BREAKER RATING	CONTACTOR RATING	VOLTAGE	LOAD (KVA)
---	MAIN	200 AMP	N/A	240	X
A	ILLUMINATION A	30 AMP	30 AMP	240	X
B	ILLUMINATION B	40 AMP	60 AMP	240	X
C	ES 326/CC 325	40 AMP	N/A	240	X
D	VMS 326	40 AMP	N/A	120	X
E	SIGNAL	50 AMP	N/A	120	X
F	SPARE	30 AMP	N/A	120	X
G	SPARE	20 AMP	N/A	120	X
H	SPARE	20 AMP	N/A	120	X
I	GFCI	20 AMP	N/A	120	X
J	HEAT STRIP	15 AMP	N/A	120	X
K	PHOTOCELL	15 AMP	N/A	120	X
BUSSWORK SHALL BE RATED AT 250 AMP MINIMUM			PEAK		X
			CONTINUOUS		X

kVA Calculations

- CKT A – 16.8 Amps x 240 volts = 4,032 w/1000 = 4.032 kVA
- CKT B – 23.1 Amps x 240 volts = 5,544 w/1000 = 5.544 kVA
- CKT C – 7500 watts / 1000 = 7.500 kVA
- CKT D – 3780 watts / 1000 = 3.780 kVA
- CKT E – 5008 watts / 1000 = 5.008 kVA
- CKT I – 1800 watts / 1000 = 1.800 kVA
- CKT J – 100 watts / 1000 = 0.100 kVA
- CKT K – 1.1 watts / 1000 = 0.0011 kVA

BREAKER SCHEDULE SUA 1
TYPE D SERVICE 120/240V

CIRCUIT	DESCRIPTION	BREAKER RATING	CONTACTOR RATING	VOLTAGE	LOAD (KVA)
---	MAIN	200 AMP	N/A	240	X
A	ILLUMINATION A	30 AMP	30 AMP	240	4.032
B	ILLUMINATION B	40 AMP	60 AMP	240	5.544
C	ES 326/CC 325	40 AMP	N/A	240	7.500
D	VMS 326	40 AMP	N/A	120	3.780
E	SIGNAL	50 AMP	N/A	120	5.008
F	SPARE	30 AMP	N/A	120	0.0
G	SPARE	20 AMP	N/A	120	0.0
H	SPARE	20 AMP	N/A	120	0.0
I	GFCI	20 AMP	N/A	120	1.800
J	HEAT STRIP	15 AMP	N/A	120	0.100
K	PHOTOCELL	15 AMP	N/A	120	0.001
BUSSWORK SHALL BE RATED AT 250 AMP MINIMUM			PEAK		X
			CONTINUOUS		X

Peak* / Continuous** load calculations

*Peak load is the sum of all loads (current) that can be drawn at any one time.
**Continuous load is the sum of all loads (current) that run for 3 hours or more continuously.
(normally you just subtract ALL gfci's and unused transformer capacity)

Peak		Continuous	
Ckt A=	4.032	Ckt A=	4.032
Ckt B=	5.544	Ckt B=	5.544
Ckt C=	7.500	Ckt C=	0.576 = **0.252(ES)+0.324(CC)**
Ckt D=	3.780	Ckt D=	1.980
Ckt E=	5.008	Ckt E=	3.208
Ckt I=	1.800	Ckt I=	0.000
Ckt J=	0.100	Ckt J=	0.100
Ckt K=	0.001	Ckt K=	0.001
	27.765 kVA		15.441 kVA

BREAKER SCHEDULE SUA 1 TYPE D SERVICE 120/240V					
CIRCUIT	DESCRIPTION	BREAKER RATING	CONTACTOR RATING	VOLTAGE	LOAD (KVA)
---	MAIN	200 AMP	N/A	240	X
A	ILLUMINATION A	30 AMP	30 AMP	240	4.032
B	ILLUMINATION B	40 AMP	60 AMP	240	5.544
C	ES 326/CC 325	40 AMP	N/A	240	7.500
D	VMS 326	40 AMP	N/A	120	3.780
E	SIGNAL	50 AMP	N/A	120	5.008
F	SPARE	30 AMP	N/A	120	0.0
G	SPARE	20 AMP	N/A	120	0.0
H	SPARE	20 AMP	N/A	120	0.0
I	GFCI	20 AMP	N/A	120	1.800
J	HEAT STRIP	15 AMP	N/A	120	0.100
K	PHOTOCELL	15 AMP	N/A	120	0.001
BUSSWORK SHALL BE RATED AT 250 AMP MINIMUM			PEAK		27.765
			CONTINUOUS		15.441

Load Calculations for Service Agreement only

- All loads are the same, except for the traffic signal circuit loads.
- Use 15 watts per display for all traffic signal and pedestrian heads. (But only if you are using all Red, Amber & Green LED displays and LED walk / don't walk displays)
- 300w + 1800w + (12*15w) + (8*15w) = 2400 watts
- 2400 watts / 1000 = 2.4 kVA

BREAKER SCHEDULE SUA 1 TYPE D SERVICE 120/240V					
CIRCUIT	DESCRIPTION	BREAKER RATING	CONTACTOR RATING	VOLTAGE	LOAD (KVA)
---	MAIN	200 AMP	N/A	240	X
A	ILLUMINATION A	30 AMP	30 AMP	240	4.032
B	ILLUMINATION B	40 AMP	60 AMP	240	5.544
C	ES 326/CC 325	40 AMP	N/A	240	7.500
D	VMS 326	40 AMP	N/A	120	3.780
E	SIGNAL	50 AMP	N/A	120	2.400
F	SPARE	30 AMP	N/A	120	0.0
G	SPARE	20 AMP	N/A	120	0.0
H	SPARE	20 AMP	N/A	120	0.0
I	GFCI	20 AMP	N/A	120	1.800
J	HEAT STRIP	15 AMP	N/A	120	0.100
K	PHOTOCELL	15 AMP	N/A	120	0.001
BUSSWORK SHALL BE RATED AT 250 AMP MINIMUM			PEAK		X
			CONTINUOUS		X

Service Agreement
Peak* / Continuous** load calculations

*Peak load is the sum of all loads (current) that can be drawn at any one time.
**Continuous load is the sum of all loads (current) that run for 3 hours or more continuously.
(normally you just subtract ALL gfci's and unused transformer capacity)

Peak		Continuous		
Ckt A =	4.032	Ckt A =	4.032	
Ckt B =	5.544	Ckt B =	5.544	
Ckt C =	7.500	Ckt C =	0.576	**= 0.252(ES)+0.324(CC)**
Ckt D =	3.780	Ckt D =	1.980	
Ckt E =	2.400	Ckt E =	0.600	
Ckt I =	1.800	Ckt I =	0.000	
Ckt J =	0.100	Ckt J =	0.100	
Ckt K =	0.001	Ckt K =	0.001	
	25.157 kVA		12.833 kVA	

BREAKER SCHEDULE SUA 1

TYPE D SERVICE 120/240V

CIRCUIT	DESCRIPTION	BREAKER RATING	CONTACTOR RATING	VOLTAGE	LOAD (KVA)
---	MAIN	200 AMP	N/A	240	X
A	ILLUMINATION A	30 AMP	30 AMP	240	4.032
B	ILLUMINATION B	40 AMP	60 AMP	240	5.544
C	ES 326/CC 325	40 AMP	N/A	240	7.500
D	VMS 326	40 AMP	N/A	120	3.780
E	SIGNAL	50 AMP	N/A	120	2.400
F	SPARE	30 AMP	N/A	120	0.0
G	SPARE	20 AMP	N/A	120	0.0
H	SPARE	20 AMP	N/A	120	0.0
I	GFCI	20 AMP	N/A	120	1.800
J	HEAT STRIP	15 AMP	N/A	120	0.100
K	PHOTOCELL	15 AMP	N/A	120	0.001
BUSSWORK SHALL BE RATED AT 250 AMP MINIMUM			PEAK		25.157
			CONTINUOUS		12.833

BREAKER SCHEDULE 005TR59645 240V - 120/240V TRANSFORMER					
CIRCUIT	DESCRIPTION	BREAKER RATING	CONTACTOR RATING	VOLTAGE	LOAD (KVA)
---	MAIN	40 AMP	N/A	240	
---	SECONDARY MAIN	60 AMP	N/A	120	
C1	CC 325	20 AMP	N/A	120	2.124
C2	ES 325	20 AMP	N/A	120	2.052
C3	GFCI	20 AMP	N/A	120	1.800
C4	SPARE	20 AMP	N/A	120	0.0
C5	SPARE	20 AMP	N/A	120	0.0
C6	SPARE	15 AMP	N/A	120	0.0
BUSSWORK SHALL BE RATED AT 100 AMP MINIMUM			PEAK		X
			CONTINUOUS		X

Transformer Breaker Schedule

Peak* / Continuous** Transformer load calculations

*Peak Transformer load is the maximum load (current) that can be drawn before Transformer Secondary Main Breaker trips open.

**Continuous load is the sum of all loads (current) connected to Transformer that run for 3 hours or more continuously.

Peak	**Continuous**	
60 Amp Secondary Main Breaker	C1	0.324
120V secondary side of transformer	C2	0.252
Watts = Amps x Volts	C3	0.000
60 Amps x 120V = 7,200 Watts		0.576 kVA
7,200 Watts / 1000 = 7.2 kVA		

BREAKER SCHEDULE 005TR59645
240V - 120/240V TRANSFORMER

CIRCUIT	DESCRIPTION	BREAKER RATING	CONTACTOR RATING	VOLTAGE	LOAD (KVA)
---	MAIN	40 AMP	N/A	240	
---	SECONDARY MAIN	60 AMP	N/A	120	
C1	CC 325	20 AMP	N/A	120	2.124
C2	ES 325	20 AMP	N/A	120	2.052
C3	GFCI	20 AMP	N/A	120	1.800
C4	SPARE	20 AMP	N/A	120	0.0
C5	SPARE	20 AMP	N/A	120	0.0
C6	SPARE	15 AMP	N/A	120	0.0
BUSSWORK SHALL BE RATED AT 100 AMP MINIMUM			PEAK		7.200
			CONTINUOUS		0.576

The clear catinkus for sizing the main breaker & busswork in a separately derived service

- Remember that this is the main breaker and branch breaker panel within a 7.5 KVA / 240 volt transformer. Therefore, 7.5 KVA is 7,500 watts at 240 volts which equals 31.25 amps. The minimum size of the breaker is 31.25 amps continuous load x 125% equals 39.06 amps load. The minimum sized branch breaker in the main service cabinet is 40 amps.
- Specify the busswork in the transformer cabinet as 100 amps minimum. In this example, call for a 6 circuit panel board with a separate main breaker.
- There is not a WSDOT standard size for a transformer cabinet main breaker. WAC 296-46B-230 Wiring and protection–Services, subsection 042 Service conductor–size and rating, requires that "if the service conductors have a lesser ampacity than the overcurrent protection or the equipment rating that they terminate in or on, an identification plate showing the ampacity of the conductors must be installed on the service equipment." If the feeder conductors are smaller than the rated busswork, the cabinet must be labeled with the ampacity of the feeder conductors feeding the busswork and also labeled with the busswork capacity. For WSDOT practices, this applies only to transformer cabinets (a separately derived service and a sub-panel from our "main" service). Downsizing of feeder conductors between the serving utility and WSDOT's main service cabinet **is not allowed** .

Any Questions?

Electrical Design Training Class

Conduit Sizing
WSDOT
Fall / Winter 2004

Presented by: Keith Calais

What is conduit fill?

- Conduit fill is the amount, in square inches, of conductors inside a section of conduit.

- NEC 2002 - Article 344 - Rigid Metal Conduit: Type RMC

- NEC 2002 – Article 352 - Rigid Nonmetallic Conduit: Type RNC (Note this Article includes PVC schedule 40 and PVC schedule 80 as well as HDPE schedule 40).

Why do we need to worry about Conduit fill?

- Dissipate heat.
- Pulling of wires.
- Potential high cost change orders when the conductors that you specified do not fit inside the conduit.

When do we need to worry about conduit fill?

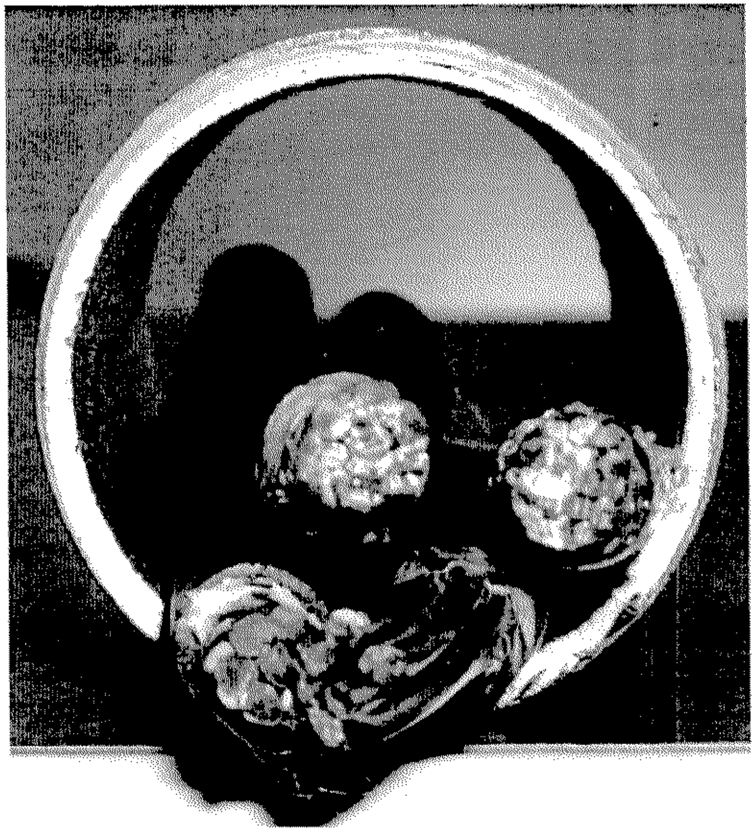
- When you are installing new conduit and conductors.

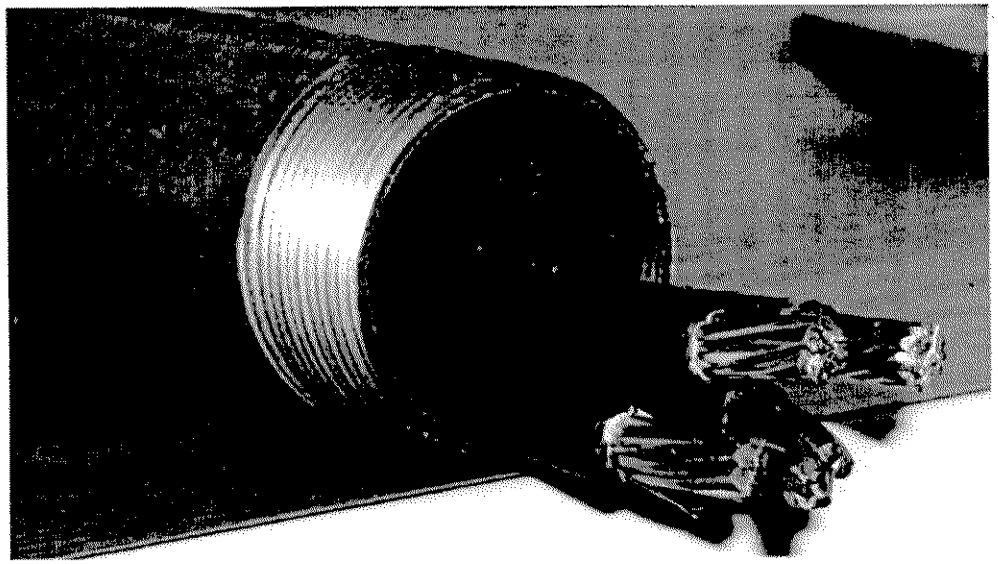
- When you are adding new conductors to an existing conduit run.

Allowable conduit fill

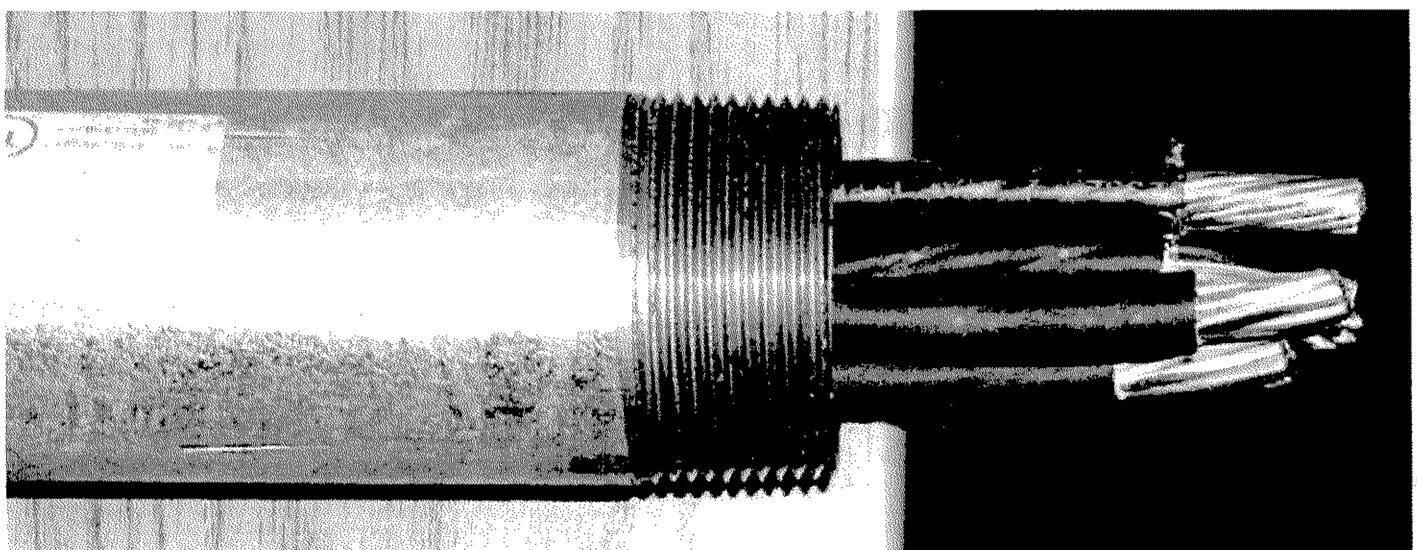
- The maximum allowable fill for new conduit is 26% full. (Design Manual Chapter 850, page 840-15 (c) Conduit)

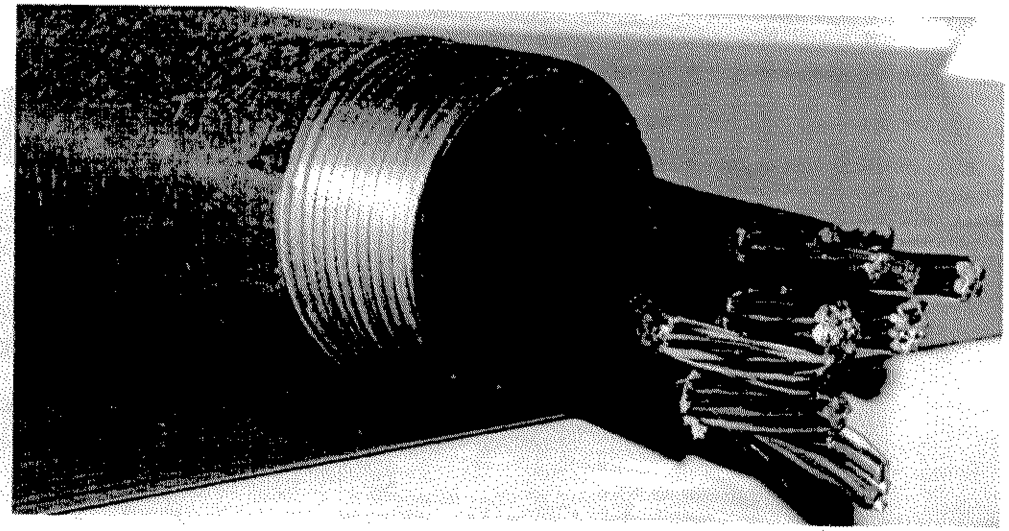
- The maximum allowable fill for existing conduits is 40% full. (NEC 2002 – Chapter 9, Table 1) and (Design Manual Chapter 850, page 840-15 (c) Conduit)



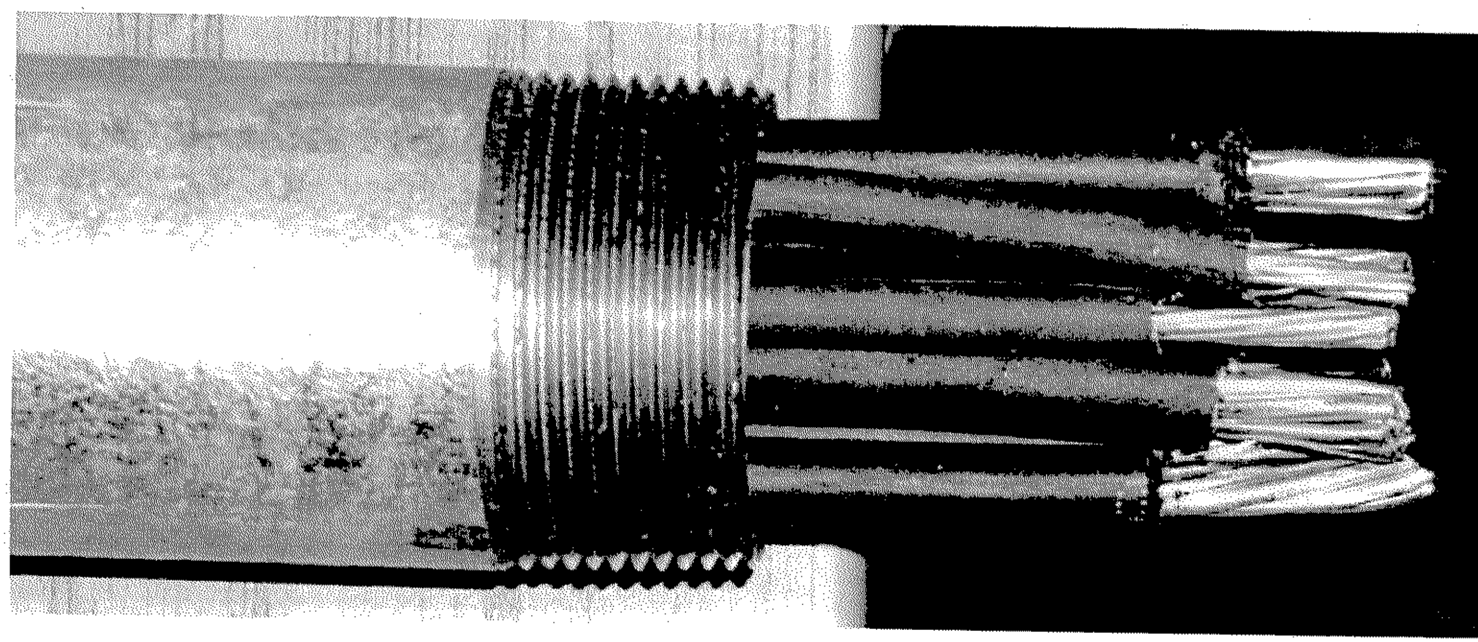


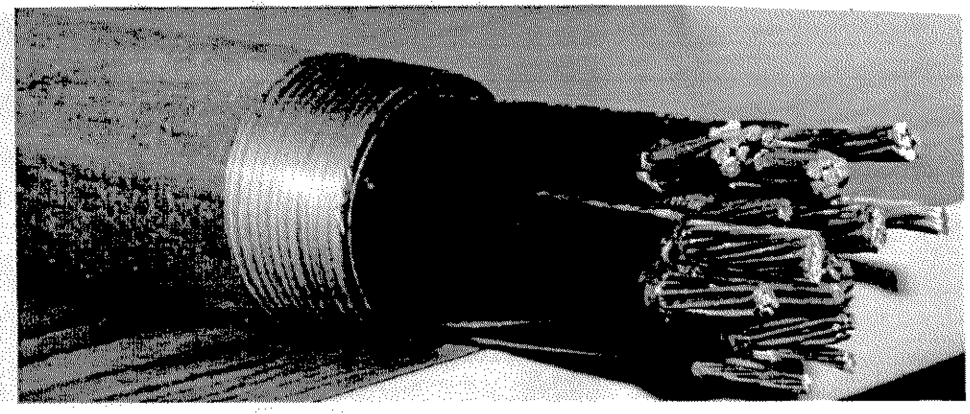
<u>26% Conduit Fill</u> → 1 ½" Conduit
Conductors → 4 - #2
= 0.532 in^2





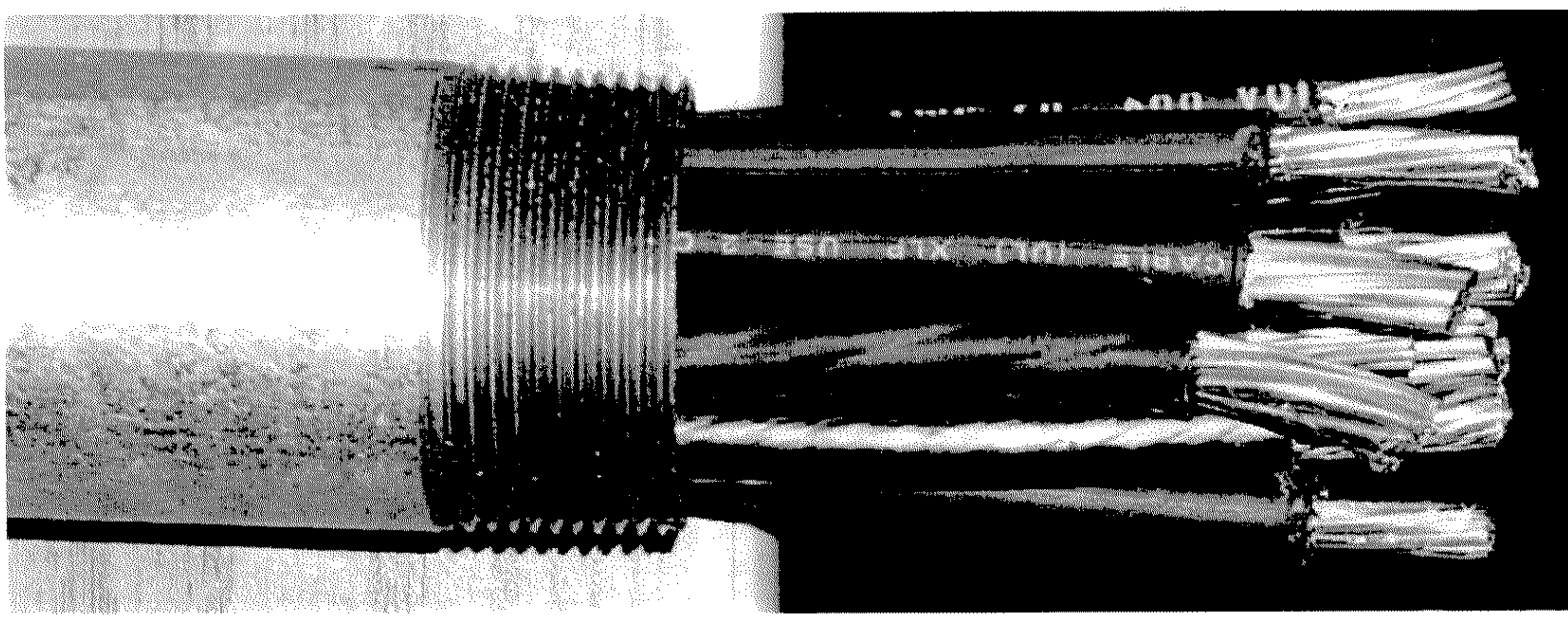
40% Conduit Fill → 1 ½" Conduit
Conductors → 4 - #2, 2 - #4, and 2 - #8
= 0.838 in^2



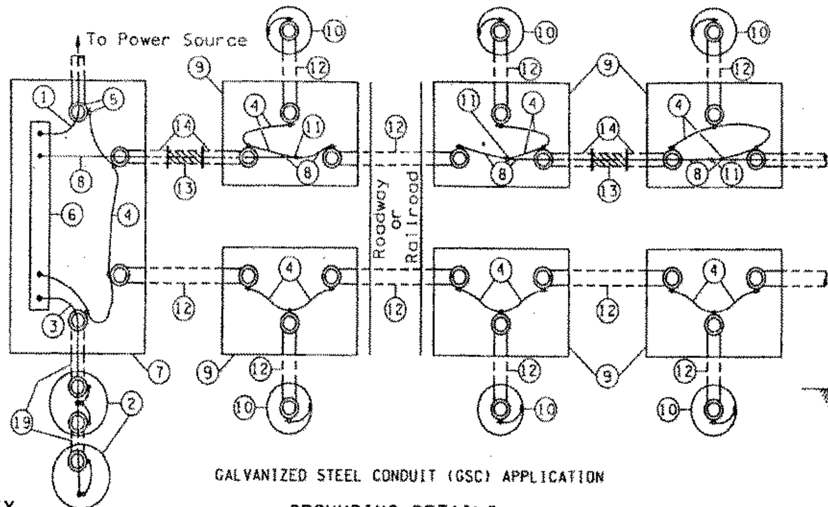


<u>60% Conduit Fill</u> → 1 ½" Conduit

Conductors → 5 - #2, 2 - #4, 2 -#6, 3 - #8, 1 - #10, and 1 - #12 = 1.232 in^2



COMBINATION GALVANIZED STEEL CONDUIT (GSC)
AND NON-METALLIC CONDUIT (NMC) APPLICATION



GROUNDING DETAILS

KEY

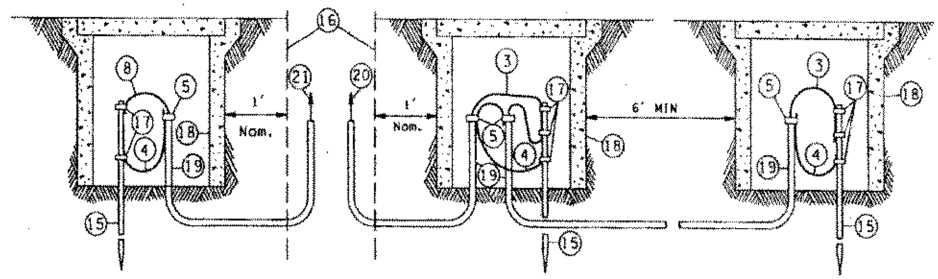
1. Service Neutral
2. Service Ground
3. Grounding Electrode Conductor
4. Bonding Jumper
5. Grounding Bushing (typ. all conduit terminations)
6. Service Neutral Bus (Copper)
7. Service Enclosure
8. Equipment Grounding Conductor
9. Junction Box
10. Electrical Load Support (luminaire pole)
11. Copper Split Bolt Clamp
12. Galvanized Steel Conduit (GSC)
13. Non-metallic Conduit (NMC)
14. Option A - 10' GSC with Field Bend
    - Approved Adapter Fitting
    - Grounding Bushing

    Option B - 10' GSC
    - GS Factory Elbows
    - Approved Adapter Fitting
    - GS Coupling
    - Grounding Bushing
15. Ground Rod
16. Edge of Foundation, Pole or Service Support
17. Clamp
18. Junction Box or 8" Drain Tile with Approved Cover
19. Code Sized GSC
20. To Service Neutral Bus
21. To Grounding Terminal or Connection to Equipment Grounding System

NOTES

1. If parallel circuits of different sizes are contained in one conduit, the size of the grounding conductor shall be determined on the basis of the largest conductor. Only one grounding conductor is required for each conduit regardless of the number of circuits contained.
2. Service ground per serving utility requirement. If the utility uses aluminum service conductors, an approved Al-Cu pressure type ground connector shall be used to secure the service neutral to the copper neutral bar in the service enclosure. Except for the above, all grounding conductors shall be copper.
3. Equipment grounding conductors and grounding electrode conductors shall be sized in accordance with the National Electric Code (No. 8 minimum).

SUPPLEMENTAL GROUND | SERVICE GROUND



Required to supplement equipment grounding for luminaire standards with direct burial, aerial feeds, or where required in plans.

Required at all services and separately derived systems.

GROUND ROD DETAILS

DAVID K. PEACH
STATE OF WASHINGTON
0011089
REGISTERED PROFESSIONAL ENGINEER
4/23/9
EXPIRES JUNE 4, 1999

TYPICAL GROUNDING DETAILS

STANDARD PLAN J-9a

APPROVED FOR PUBLICATION
Clifford E. Mansfield 4/24/98
DEPUTY STATE DESIGN ENGINEER DATE
WASHINGTON STATE DEPARTMENT OF TRANSPORTATION
OLYMPIA, WASHINGTON

DATE	REVISION	BY	APPR'D
4-99	Note 3, change "connectors" to "conductors".	ABN	

Conductor Sizes

Conductor Type	Conductor Size (in²)	Conductor Type USE	Conductor Size (in²)	Conductor Type USE	Conductor Size (in²)
2C(sh)-#14	0.090	#12	0.026	1/0	0.222
3C(sh)-#20	0.070	#10	0.033	2/0	0.262
4C(sh)-#18	0.060	#8	0.056	3/0	0.312
5C-#14	0.140	#6	0.073	4/0	0.372
7C-#14	0.170	#4	0.097	250	0.460
10C-#14	0.290	#3	0.113	300	0.528
6pcc-#19	0.320	#2	0.133	350	0.596
RG59Ucc	0.046	#1	0.190	400	0.662
24 (SM) fiber	0.196				
48 (SM) fiber	0.196				
72 (SM) fiber	0.196				
96 (SM) fiber	0.478				
144 (SM) fiber	0.478				

Conduit Sizes-GRS (2002 NEC chapter 9, table 4 - Article 344 RMC)

Conduit Size (inches)	Max Fill 26% (square inches)	Max fill 40% (square inches)
½”	0.082	0.125
¾”	0.143	0.220
1”	0.231	0.355
1 ¼”	0.397	0.610
1 ½”	0.539	0.829
2”	0.886	1.363
2 ½”	1.265	1.946
3”	1.950	3.000
3 ½”	2.603	4.004

Conduit Sizes – PVC schedule 40, and HDPE

Conduit Size (inches)	Max Fill 26% (square inches)	Max fill 40% (square inches)
½”	0.074	0.114
¾”	0.132	0.203
1”	0.216	0.333
1 ¼”	0.378	0.581
1 ½”	0.516	0.794
2”	0.856	1.316
2 ½”	1.221	1.878
3”	1.890	2.907
3 ½”	2.532	3.895

(2002 NEC chapter 9, table 4 - Article 352 RNC)

Conduit Sizes – PVC schedule 80

Conduit Size (inches)	Max Fill 26% (square inches)	Max fill 40% (square inches)
½”	0.056	0.087
¾”	0.106	0.164
1”	0.179	0.275
1 ¼”	0.322	0.495
1 ½”	0.445	0.684
2”	0.747	1.150
2 ½”	1.071	1.647
3”	1.675	2.577
3 ½”	2.259	3.475

(2002 NEC chapter 9, table 4 - Article 352 RNC)

Examples

New 1” GRS conduit with 3-#8

1” conduit 26% fill is 0.231 sq.in.

#8-0.056 sq.in. - 3*0.056=0.168 sq.in.

0.168 sq.in. < 0.231 sq.in.

Conduit fill OK.

Existing 1” GRS conduit with 5-#8

1” conduit 40% fill is 0.355 sq.in.

#8-0.056 sq.in. - 5*0.056=0.280 sq.in.

0.280 sq.in. < 0.355 sq.in.

Conduit fill OK.

Examples

New 2” GRS conduit with 6-#8, 3-#6, 4-#4, 3-#2

2” GRS conduit 26% fill is 0.89 sq.in.

#8-0.056 sq.in.	-	6*0.056=0.336 sq.in.
#6-0.073 sq.in.	-	3*0.073=0.219 sq.in.
#4-0.097 sq.in.	-	4*0.097=0.388 sq.in.
#2-0.133 sq.in.	-	3*0.133=0.399 sq.in.
		1.342 sq.in.

1.342 sq.in. > 0.89 sq.in. Conduit fill is NOT OK.

Try 3” GRS conduit 6-#8, 3-#6, 4-#4, 3-#2

3” GRS conduit 26% fill is 1.95 sq.in.

#8-0.056 sq.in.	-	6*0.056=0.336 sq.in.
#6-0.073 sq.in.	-	3*0.073=0.219 sq.in.
#4-0.097 sq.in.	-	4*0.097=0.388 sq.in.
#2-0.133 sq.in.	-	3*0.133=0.399 sq.in.
		1.342 sq.in.

1.342 sq.in. < 1.95 sq.in. Conduit fill is OK.

Examples

New 2" PVC Schedule 40 conduit with 6-#8, 3-#6, 4-#4, 3-#2

2" PVC Schedule 40 conduit 26% fill is 0.856 sq.in.

#8-0.056 sq.in.	-	6*0.056=0.336 sq.in.
#6-0.073 sq.in.	-	3*0.073=0.219 sq.in.
#4-0.097 sq.in.	-	4*0.097=0.388 sq.in.
#2-0.133 sq.in.	-	3*0.133=0.399 sq.in.
		1.342 sq.in.

1.342 sq.in. > 0.856 sq.in. Conduit fill is NOT OK.

Try 3" PVC Schedule 40 conduit 6-#8, 3-#6, 4-#4, 3-#2

3" PVC Schedule 40 conduit 26% fill is 1.890 sq.in.

#8-0.056 sq.in.	-	6*0.056=0.336 sq.in.
#6-0.073 sq.in.	-	3*0.073=0.219 sq.in.
#4-0.097 sq.in.	-	4*0.097=0.388 sq.in.
#2-0.133 sq.in.	-	3*0.133=0.399 sq.in.
		1.342 sq.in.

1.342 sq.in. < 1.890 sq.in. Conduit fill is OK.

Examples

New 2” PVC Schedule 80 conduit with 6-#8, 3-#6, 4-#4, 3-#2

2” PVC Schedule 80 conduit 26% fill is 0.747 sq.in.

#8-0.056 sq.in.	-	6*0.056=0.336 sq.in.
#6-0.073 sq.in.	-	3*0.073=0.219 sq.in.
#4-0.097 sq.in.	-	4*0.097=0.388 sq.in.
#2-0.133 sq.in.	-	3*0.133=0.399 sq.in.
		1.342 sq.in.

1.342 sq.in. > 0.747 sq.in. Conduit fill is NOT OK.

Try 3” PVC Schedule 80 conduit 6-#8, 3-#6, 4-#4, 3-#2

3” PVC Schedule 80 conduit 26% fill is 1.675 sq.in.

#8-0.056 sq.in.	-	6*0.056=0.336 sq.in.
#6-0.073 sq.in.	-	3*0.073=0.219 sq.in.
#4-0.097 sq.in.	-	4*0.097=0.388 sq.in.
#2-0.133 sq.in.	-	3*0.133=0.399 sq.in.
		1.342 sq.in.

1.342 sq.in. < 1.675 sq.in. Conduit fill is OK.

Examples

New 1 1/2" GRS conduit with 3-#8, 3-#4

1 1/2" GRS conduit 26% fill is 0.539 sq.in.

#8-0.056 sq.in. - 3*0.056=0.168 sq.in.

#4-0.097 sq.in. - 3*0.097=0.291 sq.in.

0.459 sq.in.

0.459 sq.in. < 0.539 sq.in. Conduit fill is OK.

New PVC Schedule 40 conduit with 3-#8, 3-#4

1 1/2" PVC Schedule 40 conduit 26% fill is 0.516 sq.in.

#8-0.056 sq.in. - 3*0.056=0.168 sq.in.

#4-0.097 sq.in. - 3*0.097=0.291 sq.in.

0.459 sq.in.

0.459 sq.in. < 0.516 sq.in. Conduit fill is OK.

1 1/2" PVC Schedule 80 conduit 26% fill is 0.445 sq.in.

#8-0.056 sq.in. - 3*0.056=0.168 sq.in.

#4-0.097 sq.in. - 3*0.097=0.291 sq.in.

0.459 sq.in.

0.459 sq.in. > 0.445 sq.in. Conduit fill is NOT OK.

Examples

Existing 2" GRS conduit with 6-#8, 3-#6, 4-#4, 3-#2

2" GRS conduit 40% fill is 1.36 sq.in.

#8-0.056 sq.in.	-	6*0.056=0.336 sq.in.
#6-0.073 sq.in.	-	3*0.073=0.219 sq.in.
#4-0.097 sq.in.	-	4*0.097=0.388 sq.in.
#2-0.133 sq.in.	-	3*0.133=0.399 sq.in.
		1.342 sq.in.

1.342 sq.in. < 1.36 sq.in.

Conduit fill is OK.

Things to remember when sizing conduit

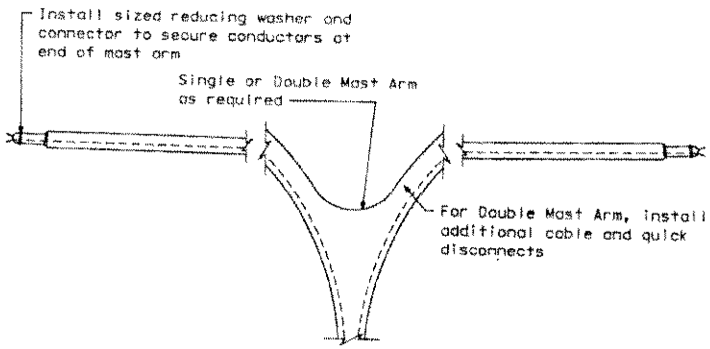
- Every time you cross a roadway put a spare conduit in.
- If the conduit crossing is for illumination or power supply, put in a spare 2” conduit.
- If the conduit crossing is for signal conduits at an intersection put in a spare 3” conduit. If the crossing is not at the intersection put in a spare 2” conduit.
- A 2” conduit should be the minimum size used for all crossings.
- Install a spare 2” conduit into a service cabinet.
- Install a spare 2” conduit between all transformers and the improvement the transformer is serving. (ITS cabinet, VMS cabinet, etc.)

Things to remember when sizing conduit.

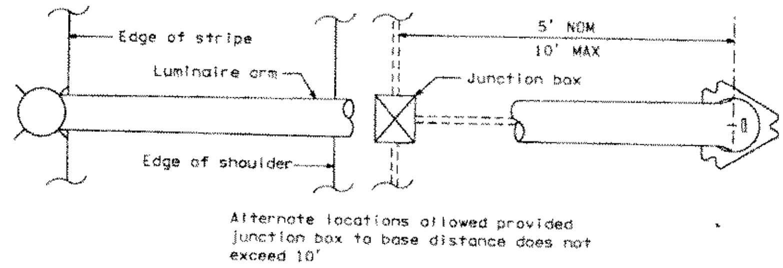
- Try not to use too many different sizes of conduit. It makes it easier to design your job and makes it easier for the contractor to build when you use less conduit sizes. Stick with even sized conduits (1", 2" 3", or 4").

- Leave room for future conductors. Running 2" conduit near the service or where there is potential for future expansion usually provides plenty of future room.

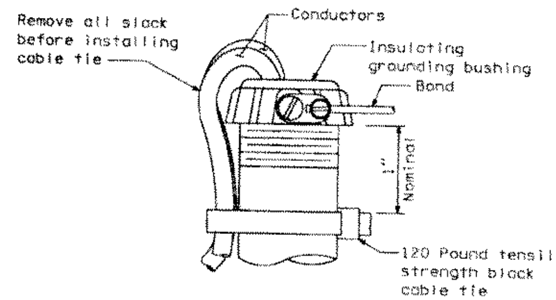
- The conduit from the luminaire pole to the adjacent junction box 5'-10' away shall be 1". This is usually the only place you would ever run a 1" conduit in grade (except the grounded electrode conductor).



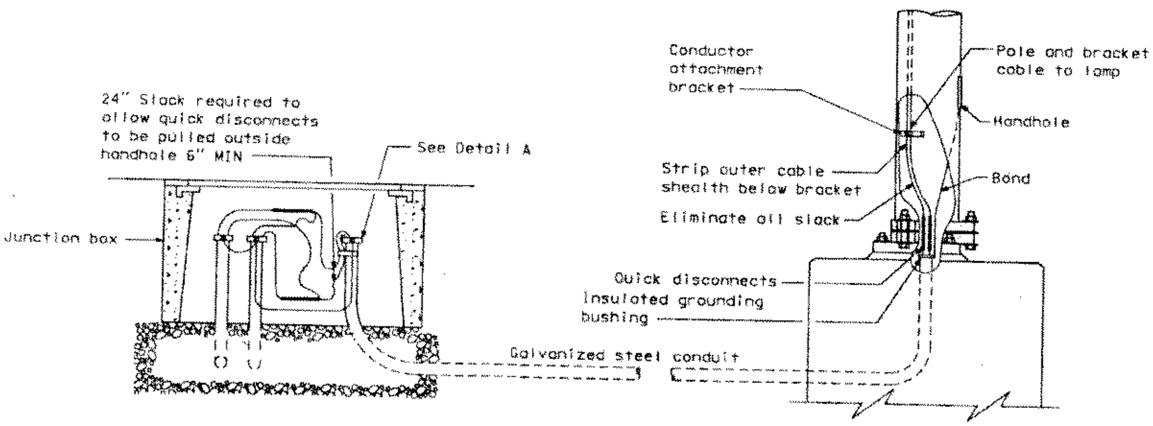
MAST ARM WIRING DETAIL



TYPICAL JUNCTION BOX LOCATION



DETAIL A



WIRING DETAIL LIGHT STANDARD SLIP BASE*

*Application for fixed base similar except no cable tie is required at junction box.

LIGHT STANDARDS WIRING DETAILS

STANDARD PLAN J-1e

APPROVED FOR PUBLICATION
Clifford E. Mansfield 8/1/97
STATE DESIGN ENGINEER DATE
WASHINGTON STATE DEPARTMENT OF TRANSPORTATION
OLYMPIA, WASHINGTON

Any Questions?

NEMA Junction Box Sizing, Conductor Bending Radii & Fiber Optic Cable

from: NEC 2002 - Article 314.28, Article 314.54 & Article 770

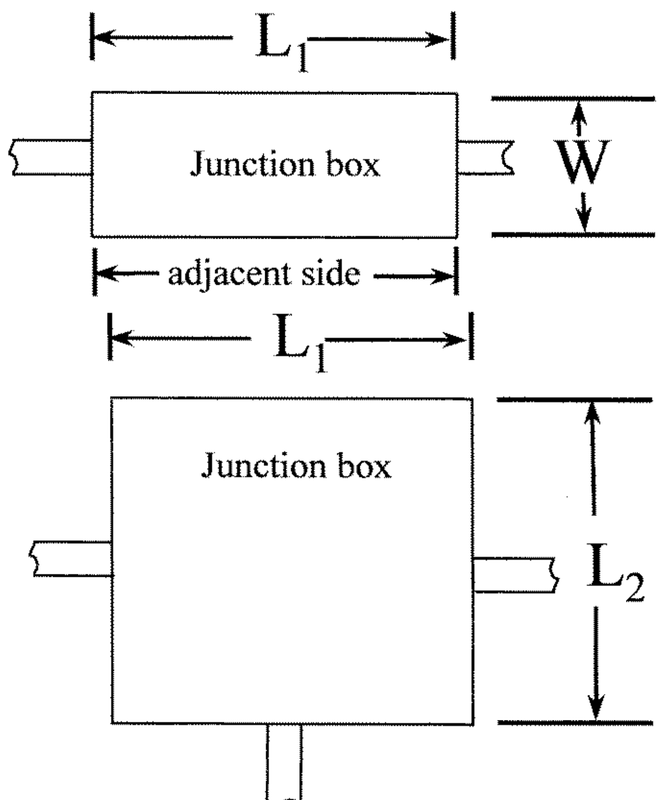
WSDOT

Fall / Winter 2004

Presented by: Terry Thayer

The clear catinkus for Junction Box Sizing and Depth

- The definition of length and width



$L_{(1)}$ or $L_{(2)}$ = (8) largest conduit in row plus the sum of all other conduits in row. Calculate for all rows and use sum of largest row.
W=(6) largest conduit in row plus the sum of all other conduits in row. Calculate for all rows and use sum of largest row. NOTE: If no conduit enters the adjacent sides of the box the dimension is width.

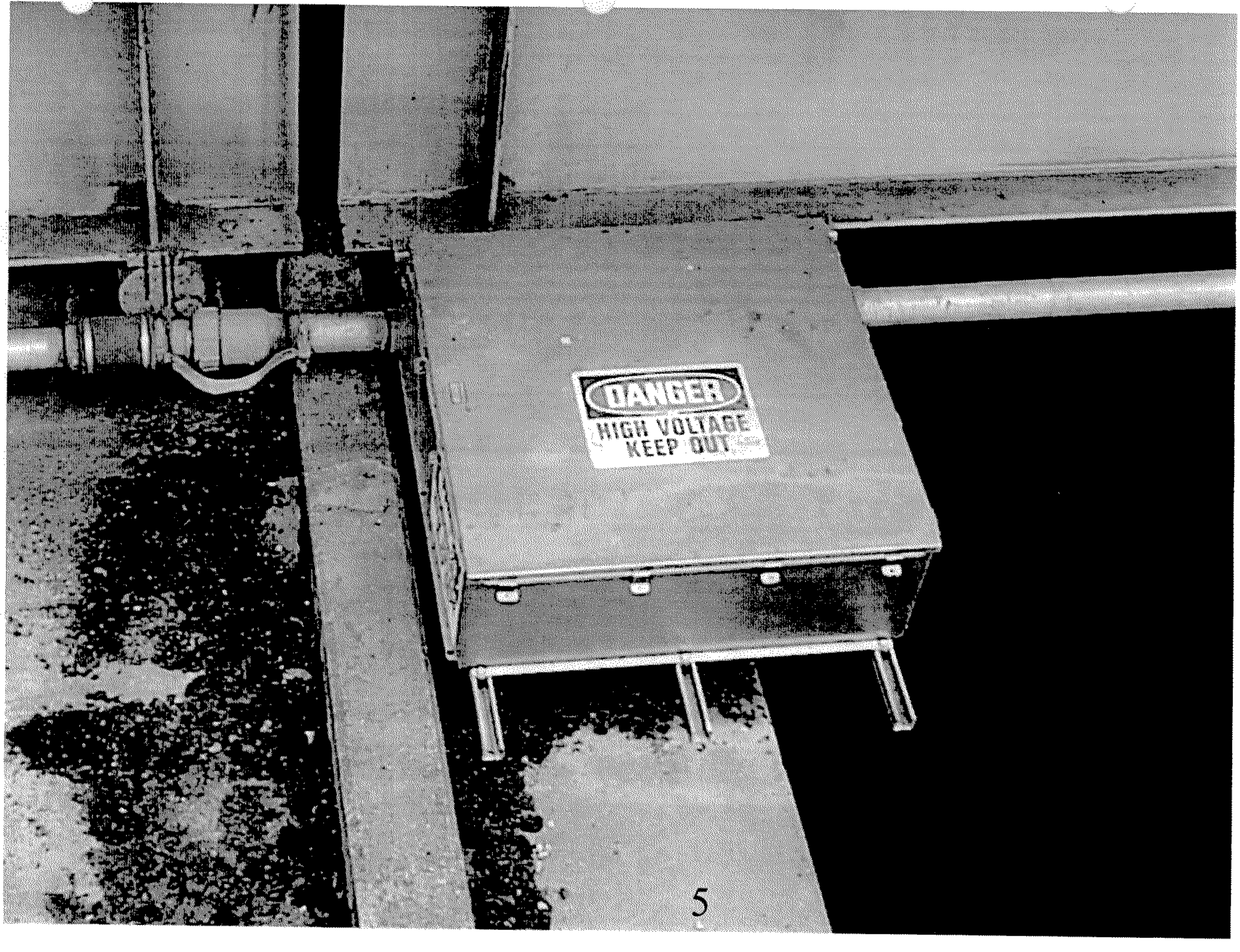
GRS conduit grounded end bushing size table			
Size	diameter inches		
Inches	External	add this number for end bushing size - then round up to nearest quarter	end bushing outside diameter
1/2	0.840	0.75	1 1/2
3/4	1.050	0.75	1 3/4
1	1.315	0.75	2
1 1/4	1.660	0.75	2 1/2
1 1/2	1.900	0.75	2 3/4
2	2.375	0.75	3 1/4
2 1/2	2.875	1.00	4
3	3.500	1.25	4 3/4
3 1/2	4.000	1.25	5 1/4
4	4.500	1.75	6 1/4
5	5.563	2.00	7 1/2
6	6.625	2.00	8 3/4
Example: A 1 1/4" GRS conduit is 1.660" + 0.75" = 2.410". Round 2.410" up to 2.5" or 2 1/2 inches.			

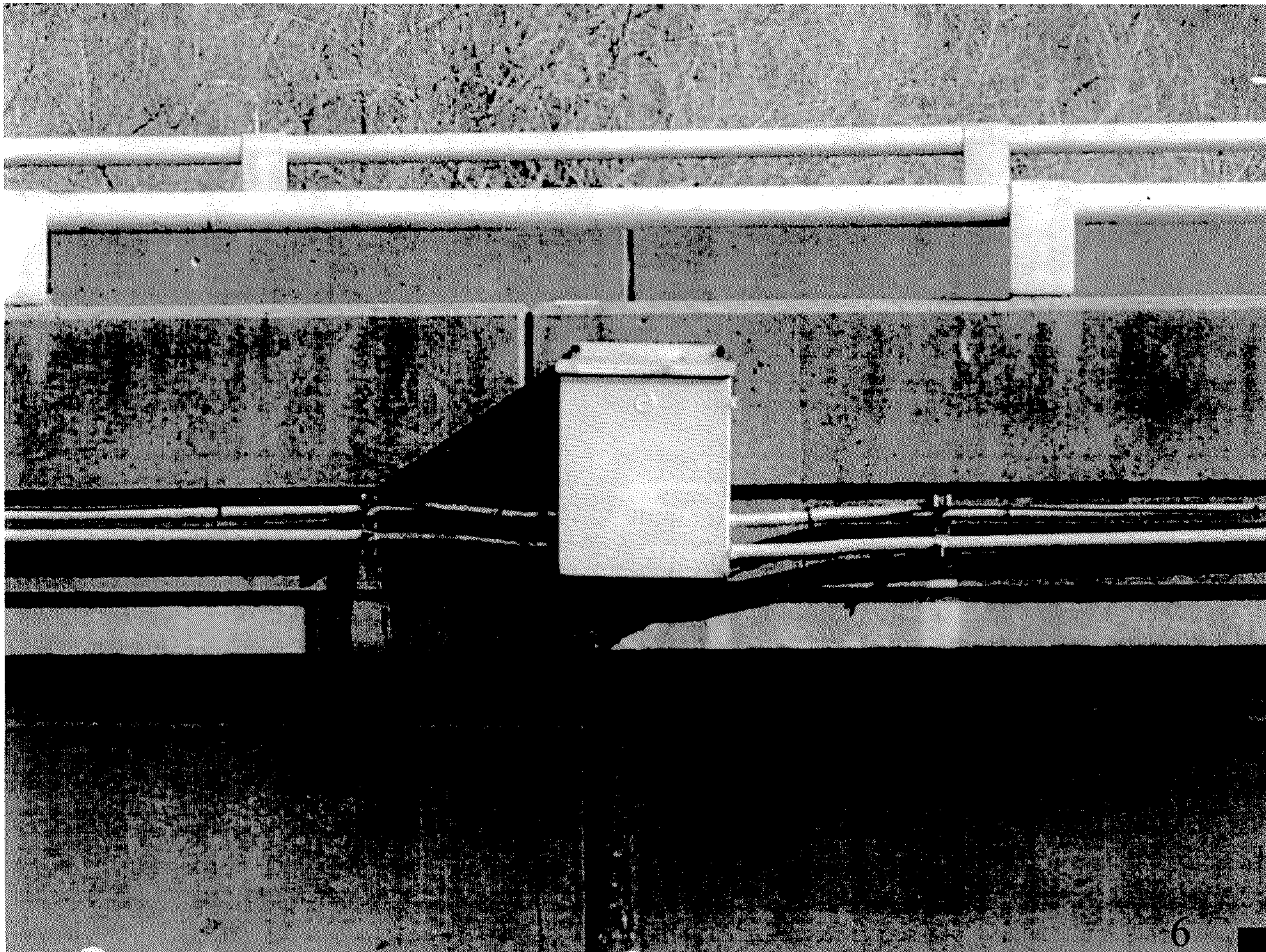
Junction Box Length - straight pull

- If one or more of the conductors is a # 4 or larger,
- Then the length is not less than 8x the diameter of the largest conduit if a through pull, regardless of the number of conduits or conductors. We use this multiplier: (8x the largest conduit plus the sum of all the other conduit diameters in the same row) for all wire sizes to avoid future undersized junction box problems.
- This assumes no bending and minimal wire storage.

- (NEC 2002 - Article 314.28 for sizing of junction boxes, Article 314.54 directs us to use methods in Article 314.28.)

4

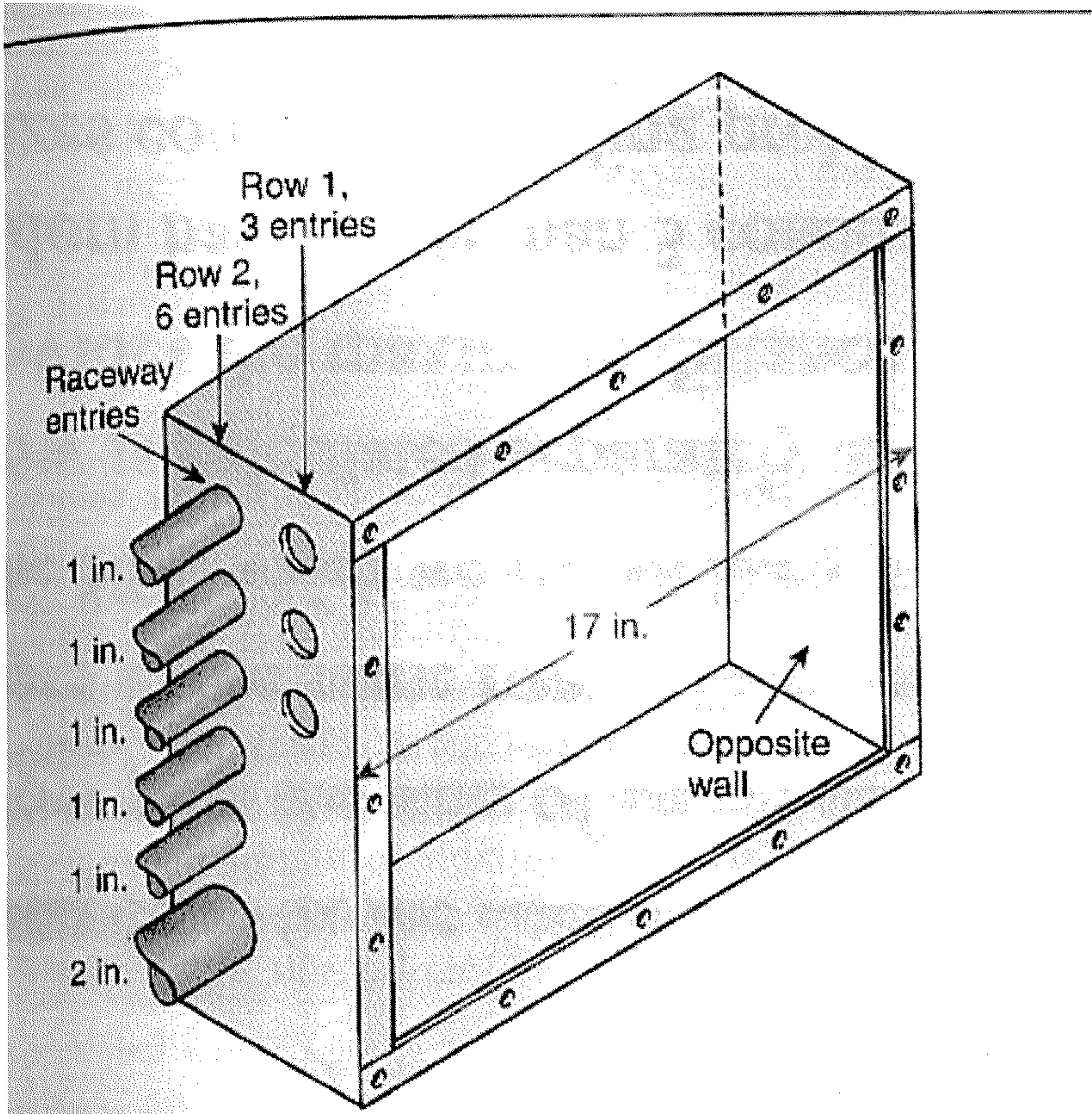

DANGER
HIGH VOLTAGE
KEEP OUT



6

Junction Box Lengths - Angle or U Pull or with splices

- The distance is 6x the diameter of the largest conduit in the row plus the sum of all the other conduit diameters in the same row. (There are exceptions to this in the NEC which we are not likely to encounter.)
- Each row is calculated separately and the single row that provides the maximum distance shall be used.
- We seldom have more than 3 conduits in a side. This minimizes conductor bending problems.



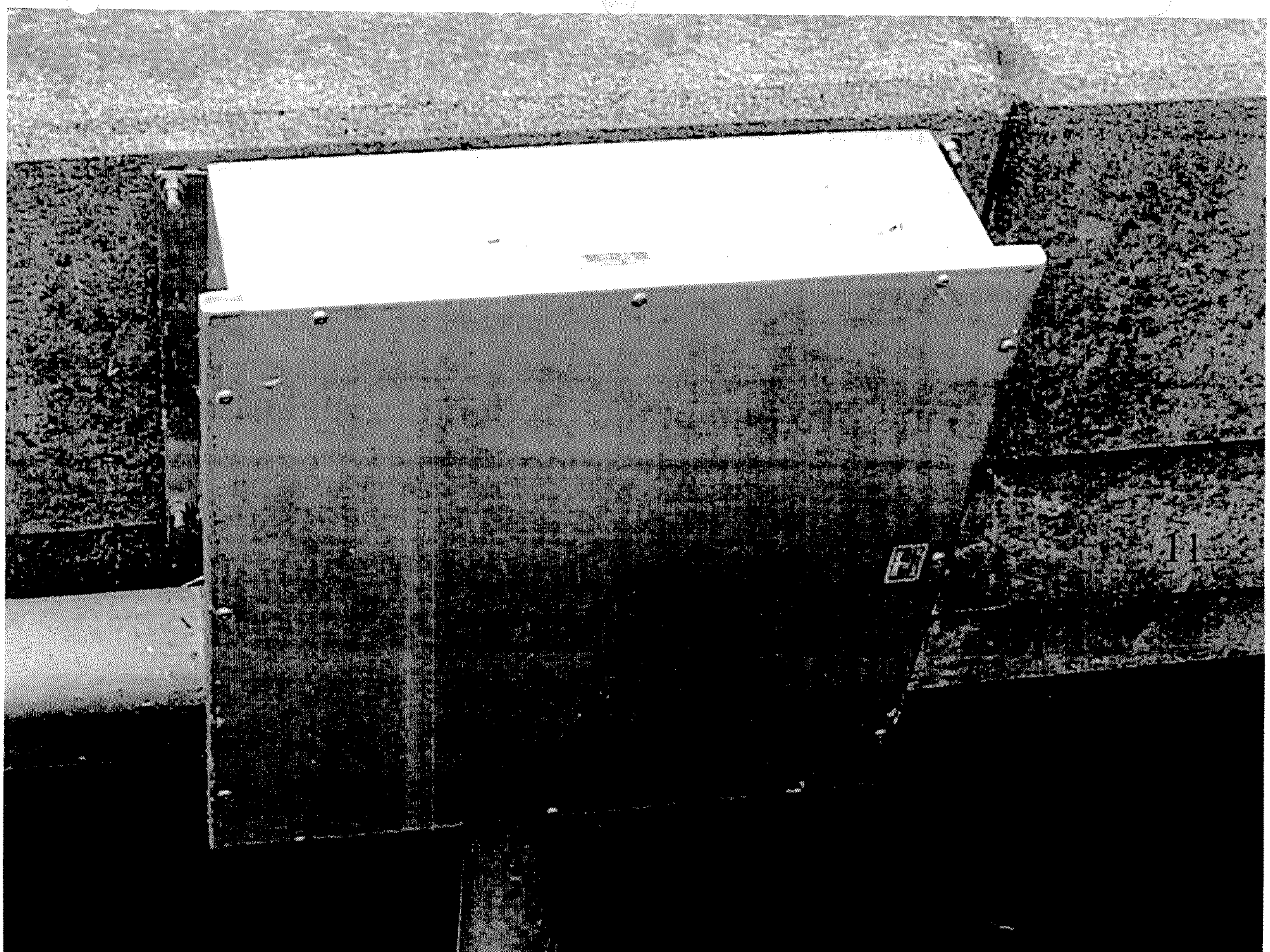
6 x 2 in. (trade diameter of largest raceway) = 12 in.
12 in. + 5 in. (sum of diameters of other entries, row 2 only)
= 17 in. (min. required from each entry to opposite wall)

Exhibit 314.10
An example showing calculations required by 314.28(A)(2) for splices, angle pulls or U pulls.

From 2002 NEC Handbook, page 313.


8 AMP FUSE
INSIDE BOX
water tight conduit
fitting (Meyers Hub)

10


11

Junction Box Depth

- The box needs only to be as deep as is needed to install the conduits and their fittings.
- Consider grounded end bushing size (diameter) in relationship to the conduit.
- Always round up to the nearest even dimension. Unless space is restricted, round up to the next (second) even dimension. (for a 1¼ inch conduit with a 2¼ inches O.D. grounded end bushing round up to 4 inches as a minimum but in most cases round up again and call out 6” as the depth)
- Junction boxes should be positioned to allow all conduits to enter from the ends.
- This reduces the effort required by the contractor during construction, allows for easier conductor installation and allows us to use smaller boxes.

Radius of Conduit Bends - NEC 344.24 and 352.24

Conduit Size	Conduit Size	One shot & full shoe bender	One shot & full shoe bender	Other Bends	Other Bends
Metric Designator	Trade Size	mm	inch	mm	inch
16	1/2	101.6	4	101.6	4
21	3/4	114.3	4 1/2	127	5
27	1	146.05	5 3/4	152.4	6
35	1 1/4	184.15	7 1/4	203.2	8
41	1 1/2	209.55	8 1/4	254	10
51	2	241.3	9 1/2	304.8	12
63	2 1/2	266.7	10 1/2	381	15
78	3	330.2	13	457.2	18
91	3 1/2	381	15	533.4	21
103	4	406.4	16	609.6	24
129	5	609.6	24	762	30

1) Use entire chart for GRS conduit. (NEC 344.24)

2) For field bending of PVC, use the “other bends” columns only. (NEC 352.24)

Radius of Conduit Bends - NEC 353.24 (2005)

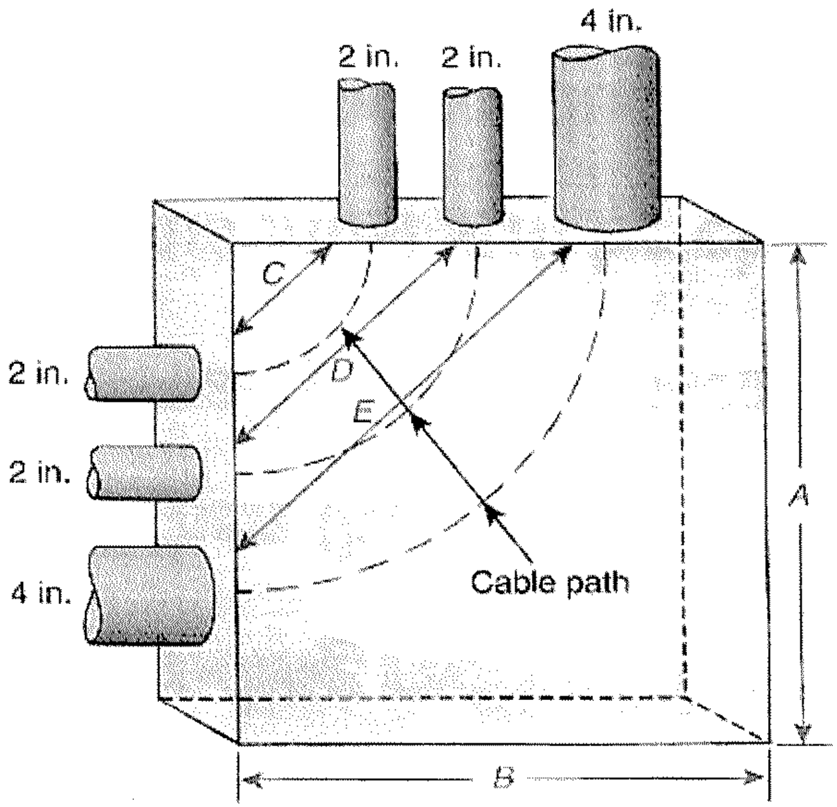
Conduit Size	Conduit Size	Minimum Bending Radius	Minimum Bending Radius
Metric Designator	Trade Size	mm	inch
16	1/2	250	10
21	3/4	300	12
27	1	350	14
35	1 1/4	450	18
41	1 1/2	500	20
53	2	650	26
63	2 1/2	900	36
78	3	1200	48
103	4	1500	60

1) Use this chart for HDPE conduit only.

Conductor Bending Radii

- There should be consideration given to the minimum bending radii of the conductors.
- When the junction box is sized properly this will not usually be a problem.
- This must still be checked to insure there is proper space for conductor bend Radii.

Conductor Bending Radii

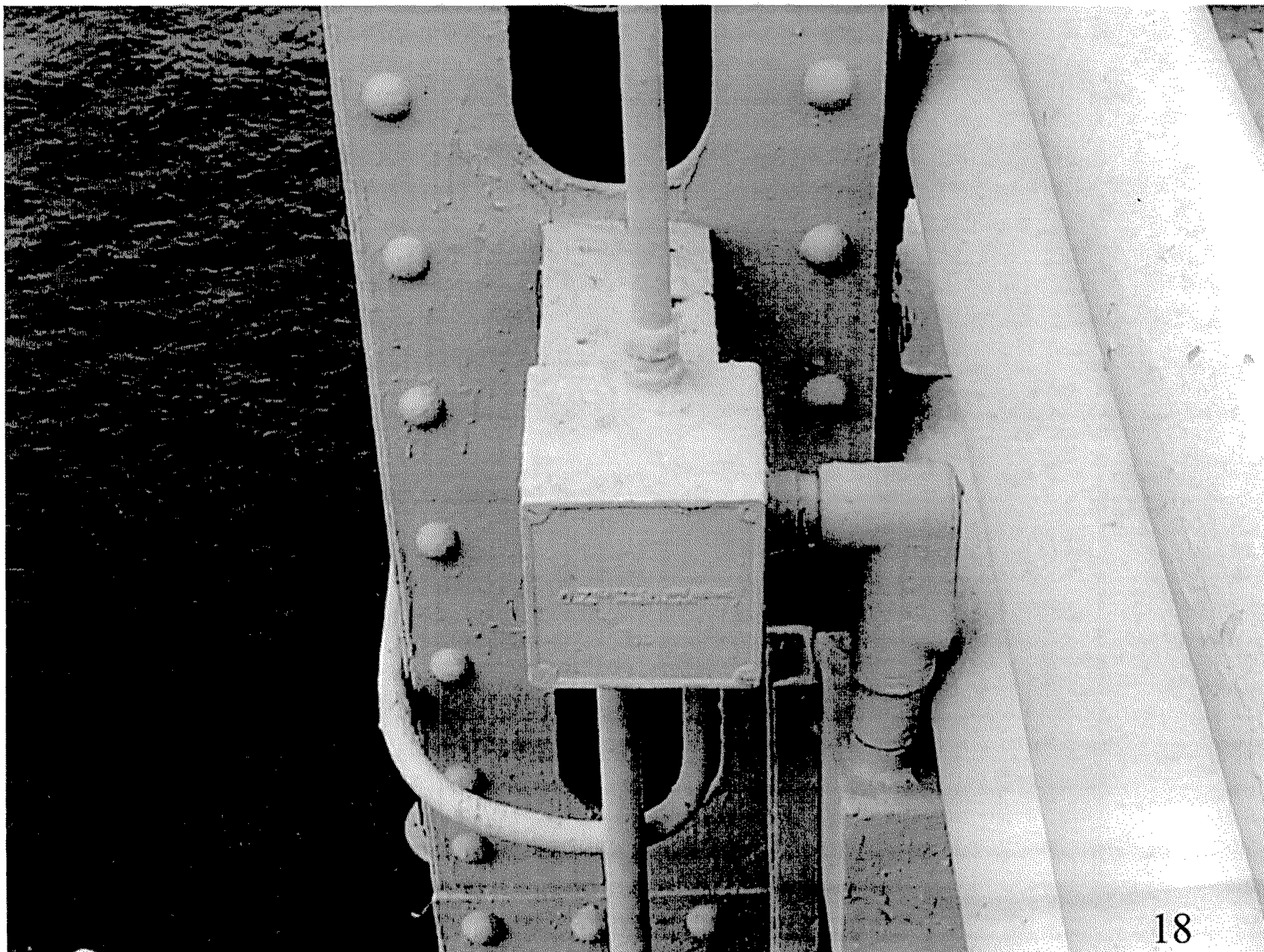


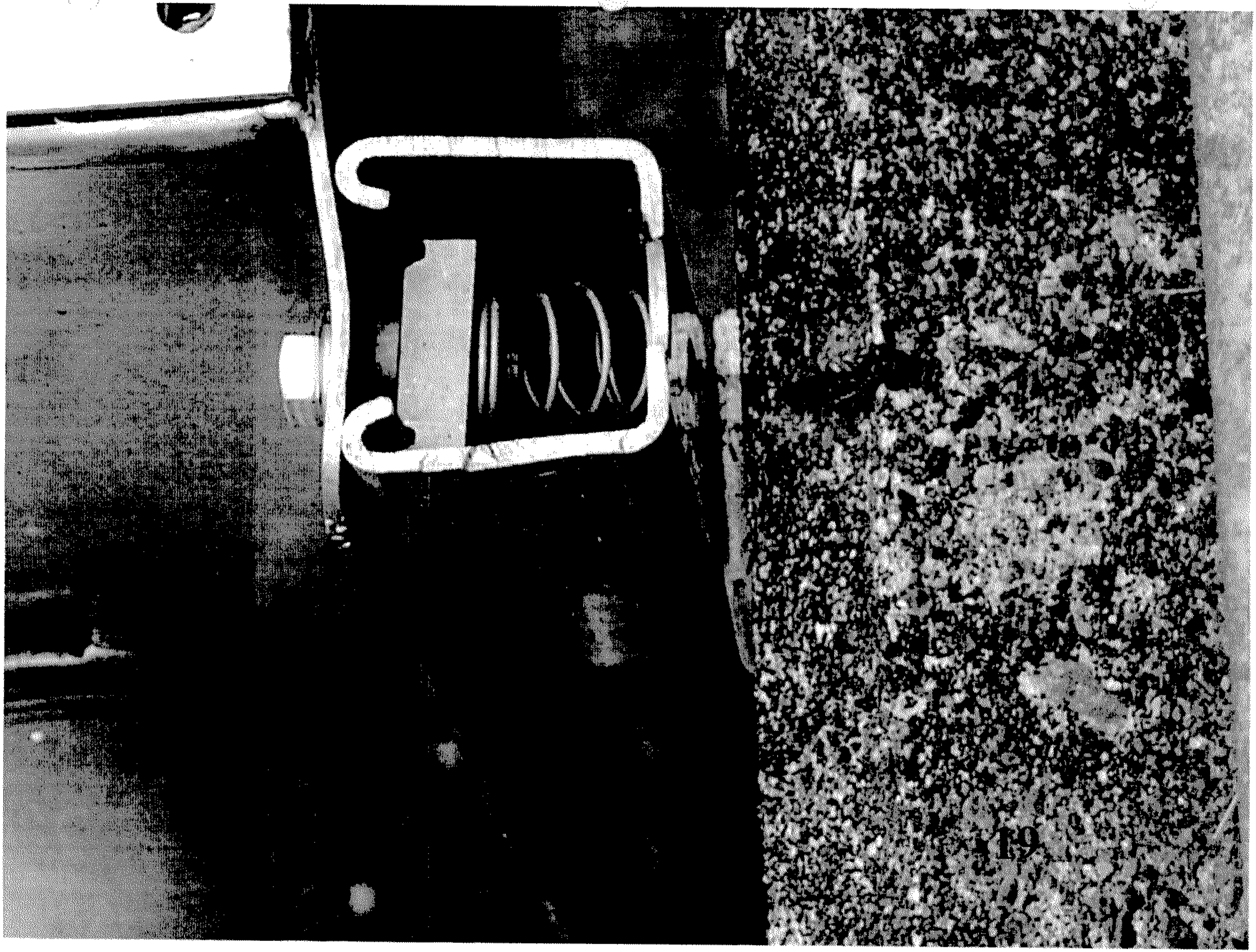
A = (6 × 4 in.) + 2 in. + 2 in. = 28 in. min.
B = (6 × 4 in.) + 2 in. + 2 in. = 28 in. min.
C = 6 × 2 in. = 12 in. min. required between raceways enclosing the same conductor
D = 6 × 2 in. = 12 in. min. required between raceways enclosing the same conductor
E = 6 × 4 in. = 24 in. min. required between raceways enclosing the same conductor

A =(6 x 4 In.) + 2 in.+2 In. +28 In. minimum
B =(6 x 4 In.) + 2 In. +2in.+ 28 In. minimum
C = 6 x 2 In. = 12 In. minimum required between raceways enclosing the same conductor
D = 6 x 2 In. = 12 In. minimum required between raceways enclosing the same conductor
E = 6 x 4 In. = 24 In. minimum required between raceways

enclosing the same conductor

Exhibit 314.11 *Raceway entries enclosing the same conductors are required to have a minimum separation between them. The intent is to provide adequate space for the conductor to make the bend.*





Conductors

2002 NEC 300.34 Conductor Bending Radius. The conductor shall not be bent to a radius less than 8 times the overall diameter for nonshielded conductors or 12 times the diameter for shielded or lead covered conductors during or after installation. For multicolor or multiplexed single conductor cables having individually shielded conductors, the minimum bending radius is 12 times the diameter of the individually shielded or 7 times the overall diameter, whichever is greater.

Conductors & Cable

CONDUCTOR	OUTSIDE DIA	MULTIPLIER	BENDING RADIUS
# 8	0.266	8	2.128"
# 6	0.304	8	2.432"
# 4	0.352	8	2.816"
# 2	0.412	8	3.296"
	(ind.cond.)	(ind.conductor)	
#2c(#14)	0.326 (0.14)	7(12)	2.282"
#3c(#20)	0.35 (0.07)	7(12)	2.45"
#4c(#18)	0.41 (0.09)	7(12)	2.87"
#5c(#14)	0.51 (0.14)	7(12)	3.57"
#7c(#14)	0.55 (0.14)	7(12)	3.85"
6pr(#19)	0.56 (0.08)	7(12)	3.92"
24 (SM) fiber	0.47	20	9.40"
48 (SM) fiber	0.47	20	9.40"
72 (SM) fiber	0.47	20	9.40"
96 (SM) fiber	0.78	20	15.60"
144 (SM) fiber	0.78	20	15.60"

Conductors

- There should be consideration given for the slack required in the conductors.
- Standard specification 8-20.3(8) requires sufficient slack wire be installed to allow any conductor to be raised 18'' outside of the junction box.
- Discuss this with the electrical inspectors if you have many circuits in one junction box / conduit run.
- If you had a through pull and 4 circuits, which does happen, you would need space for 24' of slack.

Conductors - continued

- There was a case with 2 conduits passing through one junction box carrying 11 conductors; that's 33' of slack in an 8''x 8'' x 18'' JB.
- The electrical inspectors will usually hold the contractor to the slack called for in a standard structure mounted (traffic barrier) junction box (8''x 8'' x 18'') because there are usually not many conductors in the run.
- Standard concrete junction boxes have the same slack requirements as surface mounted boxes.

Fiber Optic Cable

- The greater the radius of the conduit, the easier the pull.
- Use cable vaults and pull boxes wherever possible – the conduit then enters from the side of the box and eliminates 180 degrees of sweep at each box.
- Use 36" radius conduit sweeps wherever possible. This is the WSDOT standard for all jobs.
- When unable to use 36" radius sweep, use a minimum of 20 times the outside diameter of the cable to calculate the smallest radius that WSDOT will allow to be used. Note: This usually only applies inside a building or cabinet.

Any questions?

QUIZ #1 QUESTIONS

- 1) Given: one 400watt HPS luminaire @ 480VAC w/50' pole and 16' mast arm, #6 copper conductor, 500' run of wire to base of luminaire pole. (all service cabinet terminations, junction boxes & splice distances included in these lengths)
- Find: what is the voltage drop in this circuit?
- 2) Given: ITS service cabinet @120VAC - 1750 watt load.
- Find: size branch breaker
- 3) Given: 10 Kva transformer @ 240VAC - 8500 watt ITS service cabinet.
- Find: size transformer branch breaker in service cabinet.
- 4) Given: 1 each 2 inch dia, 1 each 1 1/2inch, 1 each 1 inch conduit - straight pull with splices.
- Find: size junction box.

Quiz #2 Questions

- 1) Given: one 400watt HPS luminaire @ 240VAC w/40' pole and 16' mast arm, #6 copper conductor, 350' run of wire to base of luminaire pole. (all service cabinet terminations, junction boxes & splice distances included in these lengths)
- Find: what is the voltage drop in this circuit?
- 2) Given: ITS service cabinet @120VAC - 1750 watt load.
- Find: size branch breaker
- 3) Given: 15 Kva transformer @ 480VAC - 10748 watt load for 5 ITS service cabinets. (1 ramp meter, 1 Camera Cabinet, 2 Data Stations & 1 HAR Station)
- Find: size transformer branch breaker in service cabinet.
- 4) Given: 1 each 2 1/2 inch dia, 2 each 2 inch, 1 each 1 1/2 inch conduit - straight pull with splices.
- Find: size junction box.

Special Provisions & Construction Notes

Presented by : Joe DeGroat

WSDOT

Fall / Winter 2004

SPECIAL PROVISIONS
Order of precedence

- Standard Specifications section 1-04.2 lists the order of precedence for various parts of a contract

1) Addenda
2) Proposal Form
3) Special Provisions
4) Contract Plans
5) Amendments to the Standard Specifications
6) Standard Specifications
7) Standard Plans

Observations

- Conflict resolution
- Importance
- How they can be used

Proper Use

- Should normally be used only to:
  - Supplement
  - Modify
  - Or Replace

  Material in the Standard Specifications or Amendments to the Standard Specifications

- Do not use the Special Provisions to repeat information from the Standard Specifications or other parts of the contract

Organization

Special Provisions need to be organized in the same fashion as the Standard Specifications. The categories of the Special Provisions are:

- Description
- Materials
- Construction Requirements
- Measurement
- Payment

Why Organize in this fashion?

- Since we are supplementing, modifying, or replacing portions of the Standard Specs it makes sense that we organize the provisions in the same fashion.
- Requires the designer and inspector to become familiar with the Standard Specifications
- Helps encourage respect for the Standard Specifications.
- Helps avoid repetition of material in the Standard Specifications.

Why organize in this fashion? - continued

- Makes it easier for the contractor and inspector to see what's different on each job
- Presents information in a consistent format
- Designer will know when they are changing a requirement from the Standard Specs or Amendments

Types of Special Provisions

- Headquarters General Special Provisions (GSP's)
- Regional Specifications
  - Two Types of Regional Specs
    - Canned (Also called Regional GSP's by some)
    - Job Specific

HQ General Special Provisions

- Maintained by the State Construction Office at HQ in Olympia
- Run list coding ends in a .GR8
- Cannot be modified by the Region unless the .GR8 designation is removed (this is only done in rare cases)

Regional Special Provisions

- Prepared at the Region level
- Use needs to be coordinated with the GSP's and Amendments to the Standard Specifications

Regional Special Provisions - continued

- Canned Regional Specs:
  - Don't have to reinvent the wheel for each job
  - Helps make sure the necessary language gets into the contract
  - Gives designers a good starting point
  - Helps increase consistency
  - May help create a framework for discussion among those affected by the provisions

Regional Special Provisions - continued

- Canned Regional Specs:
  - Should only be viewed as a starting point as it is not possible to create a set of special provisions which covers every possible situation
  - NWR maintains a set of Canned Regional specs which are available on our homepage at http://www.wsdot.wa.gov/regions/northwest/traffic/electricaldesign/default.htm

Regional Special Provisions - continued

- Canned Regional Specs
  - Only use the applicable specs on each job and modify when appropriate to create Job Specific provisions
  - Do not rely on an index description – read the specs before you use them
  - Specs may have been modified, make sure you are aware of any changes

Regional Special Provisions - continued

- If Canned Regional Specs are maintained a run list is typically used so that the specs can be called out in the same fashion as the GSP's. The Run list coding for the Region specs must end in something other than .GR8 (NW Region uses .DT1 for English Provisions and .DM1 for Metric Provisions)

Regional Fill In Specs

- Serve as a canned placeholder for job specific information
  - Don't use unless it's applicable & necessary
    - NWR maintains a Description Fill In, however on most jobs section 8-20.1 of the Standard Specifications is adequate

Standard Specification

8-20 ILLUMINATION, TRAFFIC SIGNAL SYSTEMS, AND ELECTRICAL

8-20.1 Description

This work shall consist of furnishing, installing and field testing all materials and equipment necessary to complete in place, fully functional system(s) of any or all of the following, types including modifications to an existing system all in accordance with approved methods, the Plans, the Special Provisions and these Specifications:

1. Traffic Signal System
2. Illumination System
3. Traffic Data Accumulation and Ramp Metering System

Unless otherwise noted, the location of signals, controllers, standards, and appurtenances shown in the Plans are approximate; and the exact location will be established by the Engineer in the field.

Beyond the Canned Specs

- Remember that additional special provisions may be needed to address job specific requirements

CONSTRUCTION NOTES

Purpose

- Picture says 1000 words but sometimes we need to add a few
- Reference applicable information or requirements
- Indicate what work is to be done at specific locations

Purpose - continued

- May also be used to convey how we will or will not let the work be accomplished, how the work will be paid for, what kind of materials can be used, or to identify work that will be done by someone other than the contractor

Should it be a note?

- Make the construction notes concise and to the point, there's only so much room on the plans, remember we can also use the special provisions, so ask yourself if it should really be on the plans or elsewhere?
- Remember, crowded plans can overwhelm users

Canned Notes

- NW Region maintains a set of canned construction notes for use as a starting point, which can be found on our Home Page
- Benefits of maintaining canned special provisions are also applicable for canned construction notes

Beyond the Canned Notes

- Additional construction notes may be needed to address job specific requirements

Preparation of Special Provisions & Construction Notes

Payment Specs

- Section 8-20.5 has some catch all payment wording which covers our electrical work in most situations. If you use a non standard bid item this wording will not apply, unless you make it applicable in your job specific payment specification.

Payment Specs - continued

- GEPAY.DT1
- **(NWR December 16, 2002)**
- **Payment**
- Section 8-20.5 is revised to read:
-
- Payment will be made in accordance with Section 1-04.1, for each of the following bid items that are included in the proposal:
-
- "Illumination System ____", lump sum.
- "Traffic Signal Display and Detection System ____", lump sum.
- "Traffic Signal Control System ____", lump sum.
- "Traffic Data Accumulation and Ramp Metering System____", lump sum.
- The lump sum contract price for "Illumination System ____", "Traffic Signal Display and Detection System ____", "Traffic Signal Control System ____", "Traffic Data Accumulation and Ramp Metering System_____", shall be full pay for the construction of the complete electrical system, modifying existing systems, or both, as shown in the Plans and herein specified including excavation, backfilling, concrete foundations, conduit, wiring, restoring facilities destroyed or damaged during construction, salvaging existing materials, and for making all required tests. All additional materials and labor, not shown in the Plans or called for herein and which are required to complete the electrical system, shall be included in the lump sum contract price.

Payment Specs - continued

- As an example, with the old payment specification, if you wanted to combine the signal and illumination work into one bid item the provision could be written as follows: "Section 8-20.5 is supplemented with the following: The lump sum contract price for "Electrical System SUA 948" shall be full pay for all work, as described in this section, on the associated signal and illumination systems powered by service SUA 948."

Proprietary Products

- If our provisions allow less than three manufacturer's for a given product, the product is considered proprietary and approval is required
- In general its a good idea to avoid using proprietary products but don't hesitate to use them if there is a good reason

Proprietary Products - continued

- If you plan on using a proprietary product, make sure to request approval early in the process so you have time to come up with another plan if approval isn't granted
- Don't use a proprietary product just to make it easier to write the specification

Proprietary Products - continued

- Avoid using the term "or equal". This term is frequently used to avoid having to get proprietary approval, however the or equal leaves us hanging out in the air. This term often ends up confusing the construction office and really doesn't put much constraint on the contractor. We never know what we are going to get when this term is used.

Catalogue Cut's

- In most cases don't copy catalogue cut's verbatim into your specs. These often aren't written properly for use in our specials and we may not want to adopt all of the material requirements.

Common Considerations

- Since special provisions and construction notes are used for a similar purpose, many of the same considerations come into play in their preparation

Remember the “big” picture

- The contract should result in economical construction of an electrical project, which is maintenance friendly and to the greatest possible extent facilitates safe, efficient, and economical travel on our State highways

Remember the “big” picture Continued

- Field Verification/Actual site conditions
- Understand overall project
- Find out about future work in the area
- Make sure you have the necessary information (speed studies, survey, traffic volumes, accident data, etc.)
- Know the current design standards

Remember the “big” picture Continued

- Coordinate with other designers as the project is developed
- Determine if there are any special considerations which need to be taken into account
- Keep cost in mind
- Use available resources and get feedback
- Don’t hesitate to ask questions
- Decide what needs to be constructed

Once you know what needs to be done

- You are half way there, the next step is to clearly and unequivocally communicate your intent

Who reads this anyway?

- Reviewers
- Construction office
- Contractor
- Anyone trying to coordinate with our work
- Arbitration or Lawyers? (Lets hope not)

General Rules

- Use of Shall, Will and Should
- Communicate through the Engineer
- Let the rest of the contract stand on its own
- Do not use phrases such as "furnish and install", or "provide new" (see Std Specs)
- Don't use qualitative phrases like "very", "good workmanship" or "first rate"

General Rules - continued

- Be careful with the term "satisfactory" – to whose satisfaction?
- Don't pass design work to the construction office or contractor
- Don't make assumptions
- Make sure there aren't conflicts within your plans
- Let the contractor know what is really involved in the work

General Rules - continued

- Think like a contractor, could I get a change order out of this? Is this constructible? Can I bid this?
- Could this be interpreted any other way than how I intend it to be?
- Make good use of references

General Rules - continued

- Make sure you've got good information, don't go off someone's "guess"
- Be consistent

Review

- An internal review should be done
- Make sure the job is biddable, constructible, and well conceived
- Make sure it is clear how the work is to be paid for, and exactly what is to be accomplished

Review - continued

- Local Agency and Developer Jobs
  - Should require that they use our material and construction provisions, no reason for them to start from scratch and much harder for our reviewer and inspector
  - As long as the State isn't paying, its OK if they use their own payment provisions

Where do we need to focus?

- There are two ways to put out a bad contract. One is misguided or ill conceived intent and the other is failure to communicate good intent.
- By far the most common cause of problems is poor communication which opens the door for incorrect interpretations. This means we may end up with change orders or we may not end up with the end product we wanted.

Change Orders

- If our design intent is not presented properly or if we fail to properly address the necessary issues in our design a change order may occur
- Change orders are very costly and embarrassing. Work can easily cost 3 times as much when its done as a change order.

Food for thought

- The concrete in the piles or shafts, whichever is constructed first, shall cure for a minimum of three days before construction of the piles or shafts, whichever is constructed last, is constructed.
- Damage to an edge that requires additional saw cutting will be done at no additional cost to the State.
- Conduit shown on drawings is either new conduit or existing conduit to be replaced. No existing conduit that is not to be replaced is shown.

Food for thought-continued

- If necessary, unsatisfactory restoration work may be accomplished by the department and billed to the utility company.
- Contractor shall install 6’ X 6’ cedar post 10’ in the air.
- Where noted in the Contract, a pedestrian in tunnel push-button, of substantially tamper-proof construction shall be furnished and installed
- Upon receiving two or more substantiated continuing complaints, the State will accomplish testing in the bedrooms of the affected residents.

Food for thought-continued

- As defined in these Special Provisions the work shall be completed in a sequence that provides for the maintenance of ferry operations and for the early completion of the remodeled and relocated passenger-only ferry facilities. The required order of the work is as follows:
  - 1. Begin Work
  - 2. Provide access to other contractor(s) for installation of modular buildings, tent structures or both
  - 3. Relocate the passenger-only ferry barge & ramps
  - 4. Complete all work necessary to commence operation of the interim passenger-only facilities in the new location.
  - 5. Complete all work.

Food for thought-continued

- No additional compensation will be made for moderate amounts of extra work required because the existing facilities vary from what is shown so long as the differences are not extreme.
- If these items are stored temporarily until they are ready to be delivered they shall be stored so that they are protected from weather, theft, vandalism, and other contractor activity.

Electrical Design class

Installing electrical conduit in bridges & structures

Presented by: Terry Thayer

WSDOT HQ Traffic Office

Fall / Winter 2004

Introduction

- This class will present you with the details required to design, review or install conduit, junction boxes, ITS(SC&DI) camera pole or luminaire bases, traffic loops or other electrical system components into or on a bridge or structure.
- Provide two 2” dia. conduits in bridge or structure, keep conduits electrically separated from each other, from grade at beginning of bridge to grade at end of bridge.

Introduction - continued

- provide expansion & deflection fittings as required and terminate each conduit off structure in a junction box.
- Provide one or two 4” dia. ITS(SC&DI) conduits across structure & terminate in pull box in grade at each end of structure.
- NOTE: install ITS conduit only if part of ITS(SC&DI) system plan.

Rules

- by agreement w/ Bridge & Structures group:
- conceal all electrical equipment within new structure.
- on existing structures place equipment under structure where possible.
- or, when installing equipment in view of traffic, try to hide equipment in form lines.

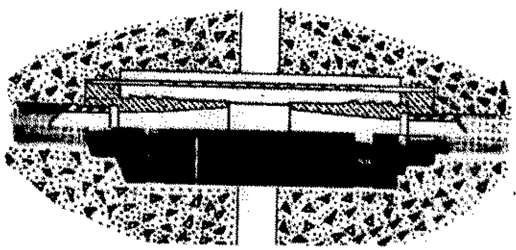
Rules - continued

- provide one set of two junction boxes in the traffic barrier every 180’ center to center across bridge or structure.
- place one set of junction boxes in the second and third dummy joint barrier section at beginning & end of bridge rail.
- space each set of junction boxes eight feet apart
- conduit enters end of junction boxes only.
- label junction boxes, in ascending roadway stationing, TS and then LT.

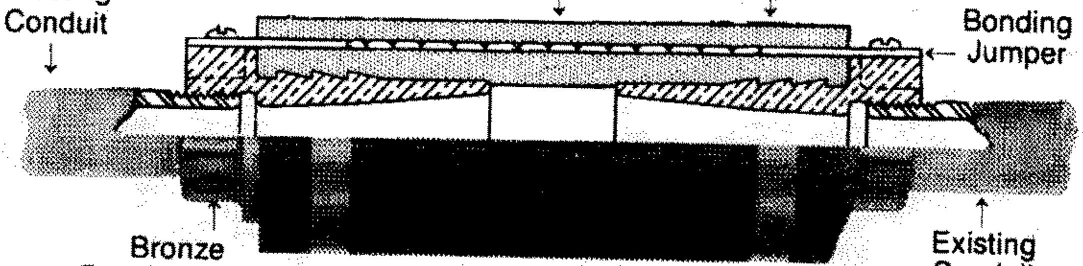
Rules - continued

- provide a junction box within ten feet of stub out for traffic loop, luminaire pole, ITS(SC&DI) camera pole, etc.
- Bridge group will calculate movement within structure & provide design locations for expansion, deflection and expansion / deflection fittings.
- place deflection fitting in retaining walls near the transverse construction joint (cold construction joint) in the footing, 120’ spacing maximum.

Deflection Fitting - DX

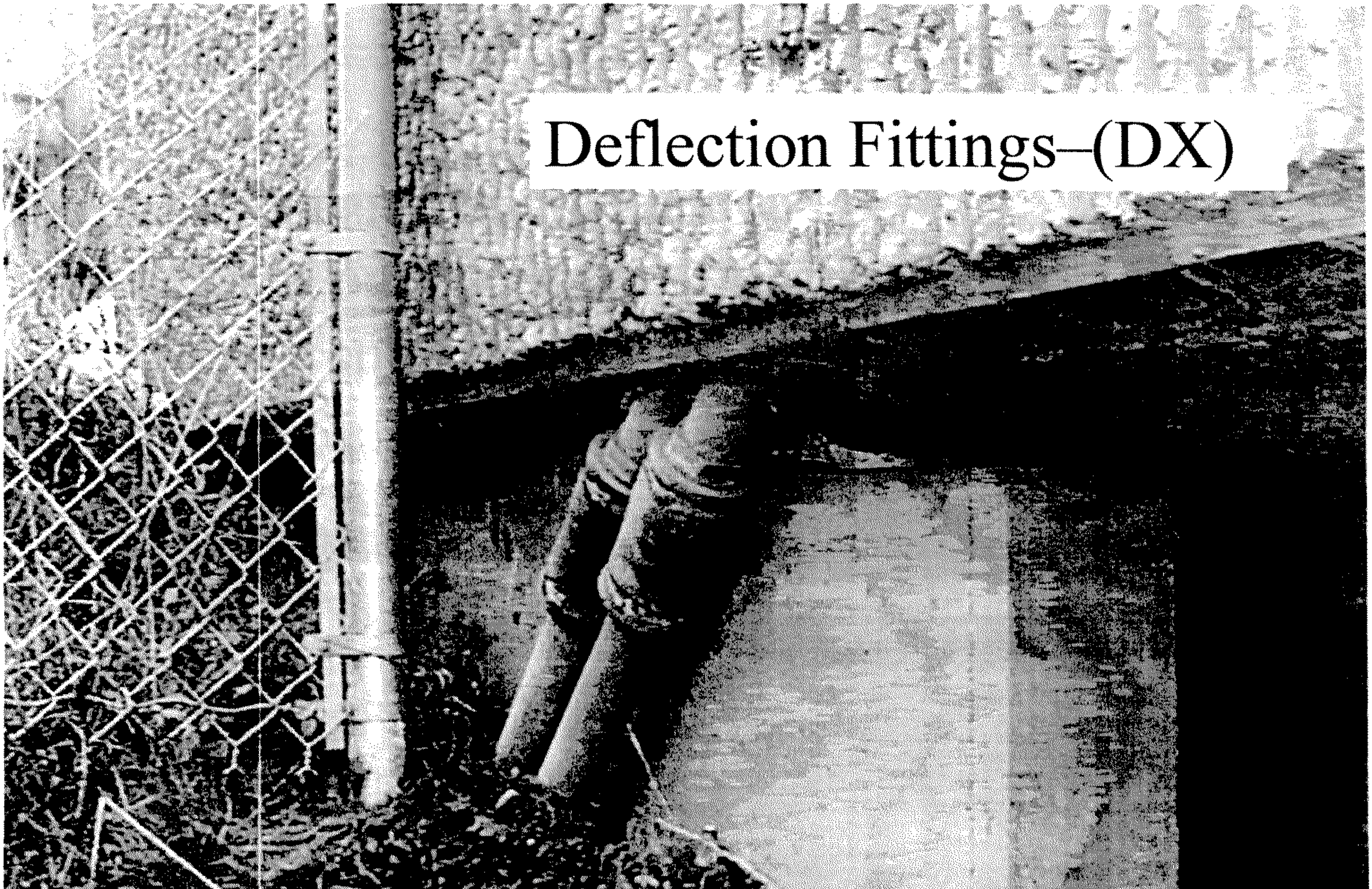


Installation in Concrete

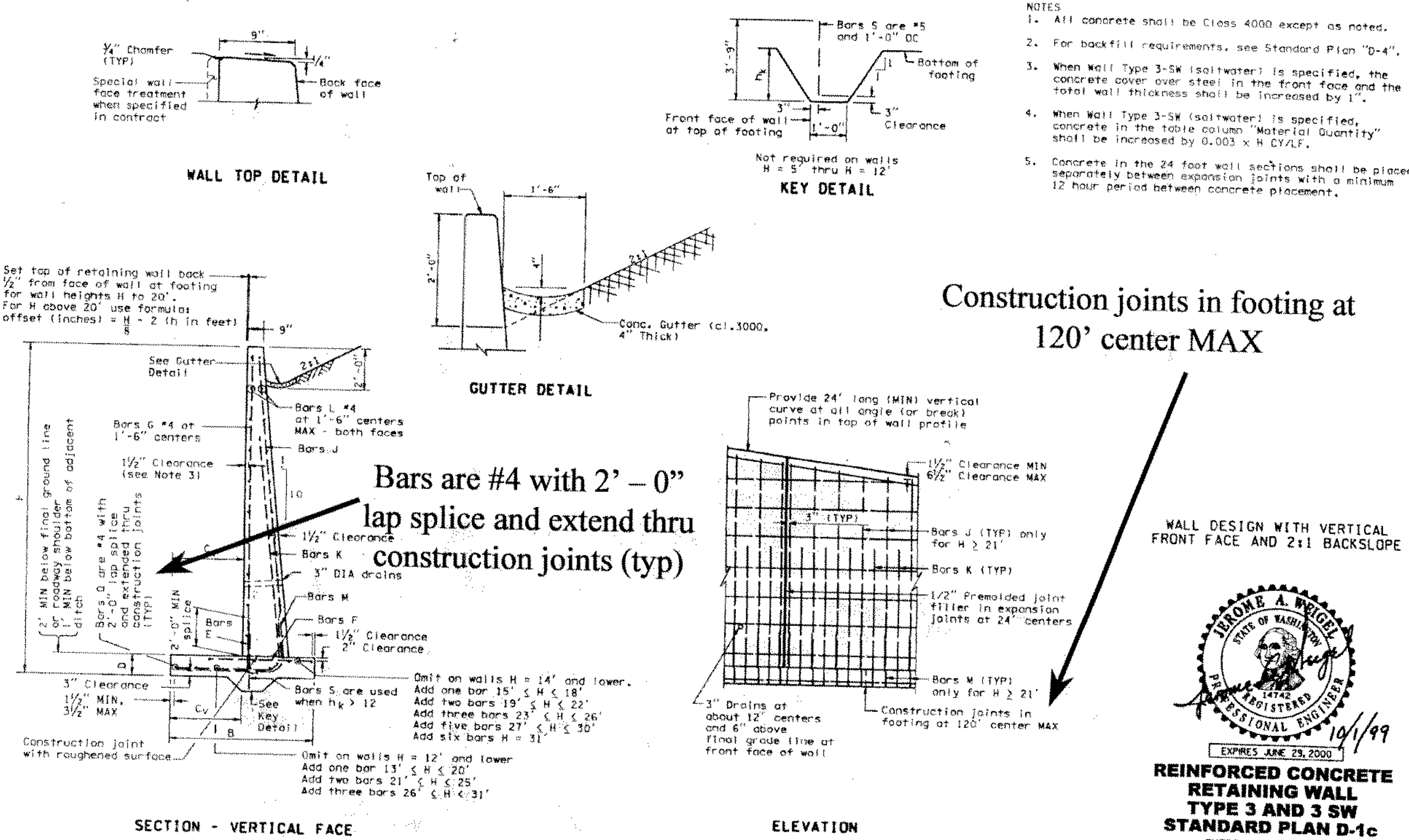


A Deflection Fitting (DX) allows for 30 degrees of bend in any direction and 3/4 inch of expansion or contraction.

Deflection Fittings–(DX)



NOTES
1. All concrete shall be Class 4000 except as noted.
2. For backfill requirements, see Standard Plan "D-4".
3. When Wall Type 3-SW (saltwater) is specified, the concrete cover over steel in the front face and the total wall thickness shall be increased by 1".
4. When Wall Type 3-SW (saltwater) is specified, concrete in the table column "Material Quantity" shall be increased by 0.003 x H CY/LF.
5. Concrete in the 24 foot wall sections shall be placed separately between expansion joints with a minimum 12 hour period between concrete placement.

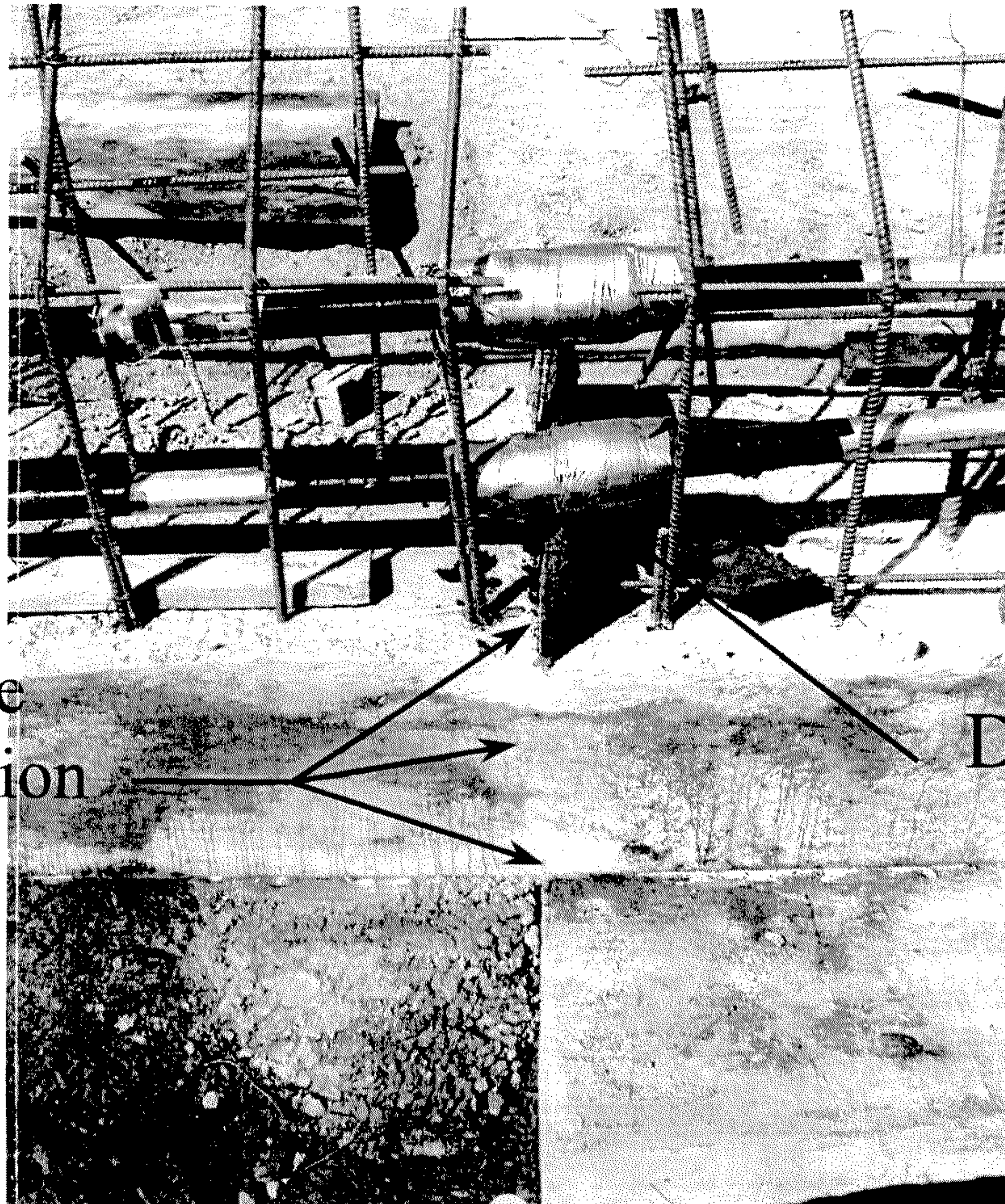


REINFORCED CONCRETE RETAINING WALL TYPE 3 AND 3 SW STANDARD PLAN D-1c

SHEET 1 OF 2 SHEETS

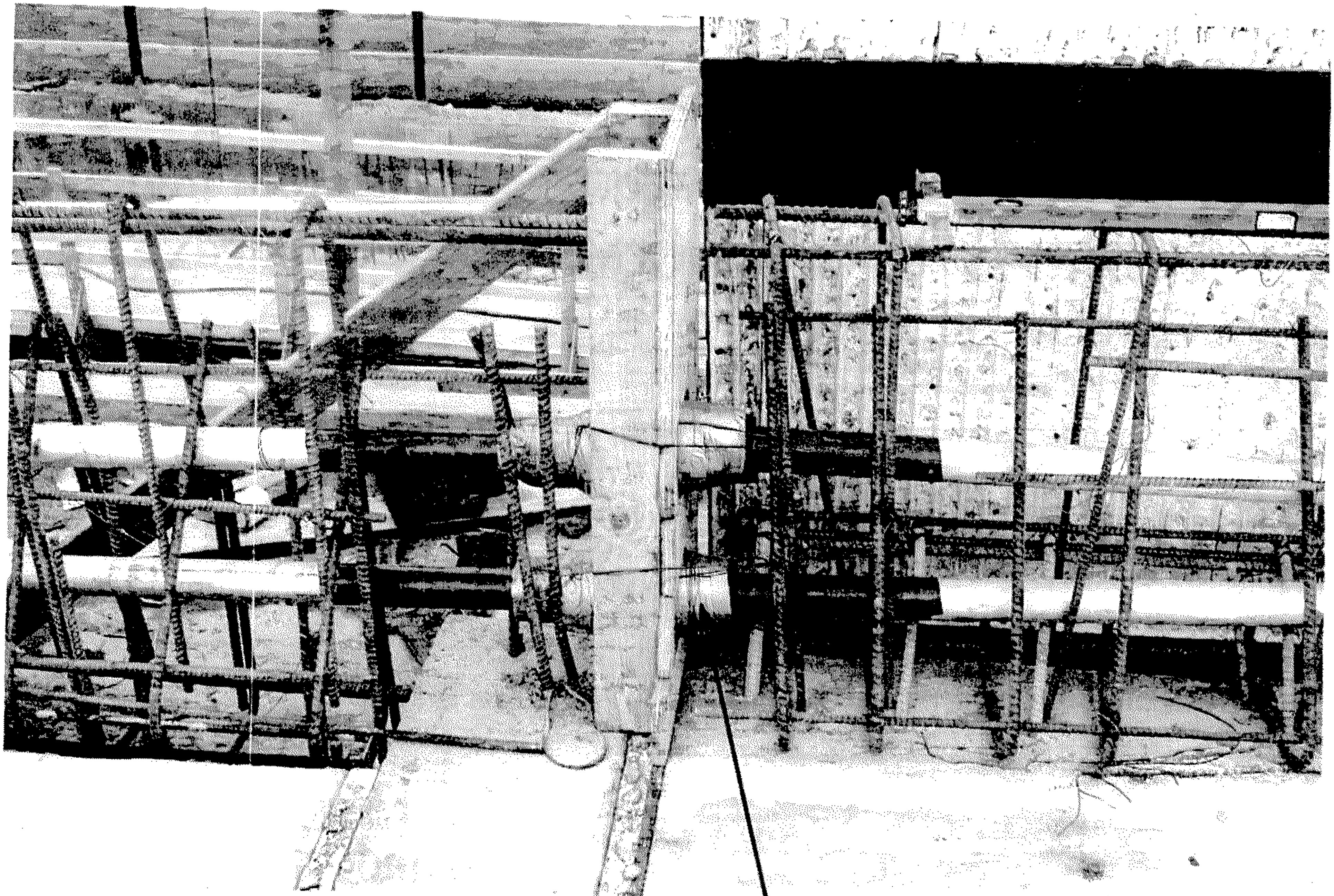
APPROVED FOR PUBLICATION
Clifford E. Mansfield 10/4/99
STATE DESIGN ENGINEER DATE
WASHINGTON STATE DEPARTMENT OF TRANSPORTATION OLYMPIA, WASHINGTON

DATE	REVISION	BY
10/99	Added note 5.	TWS



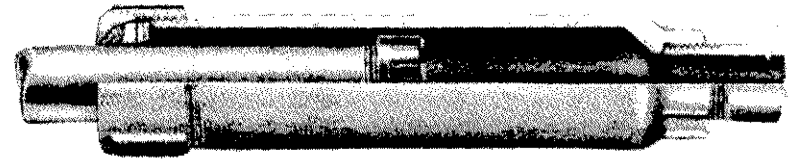
transverse
construction
joint

Deflection
Fitting
Detail B
(DX)

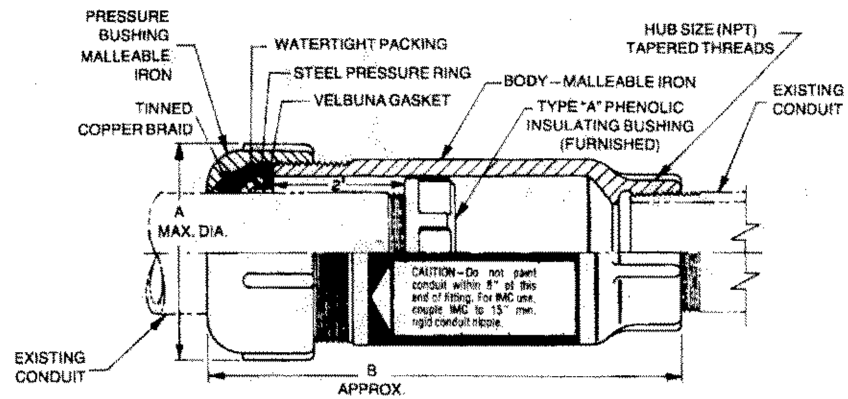


Deflection Fitting Detail B-(DX)

Conduit Expansion fitting – (AX)



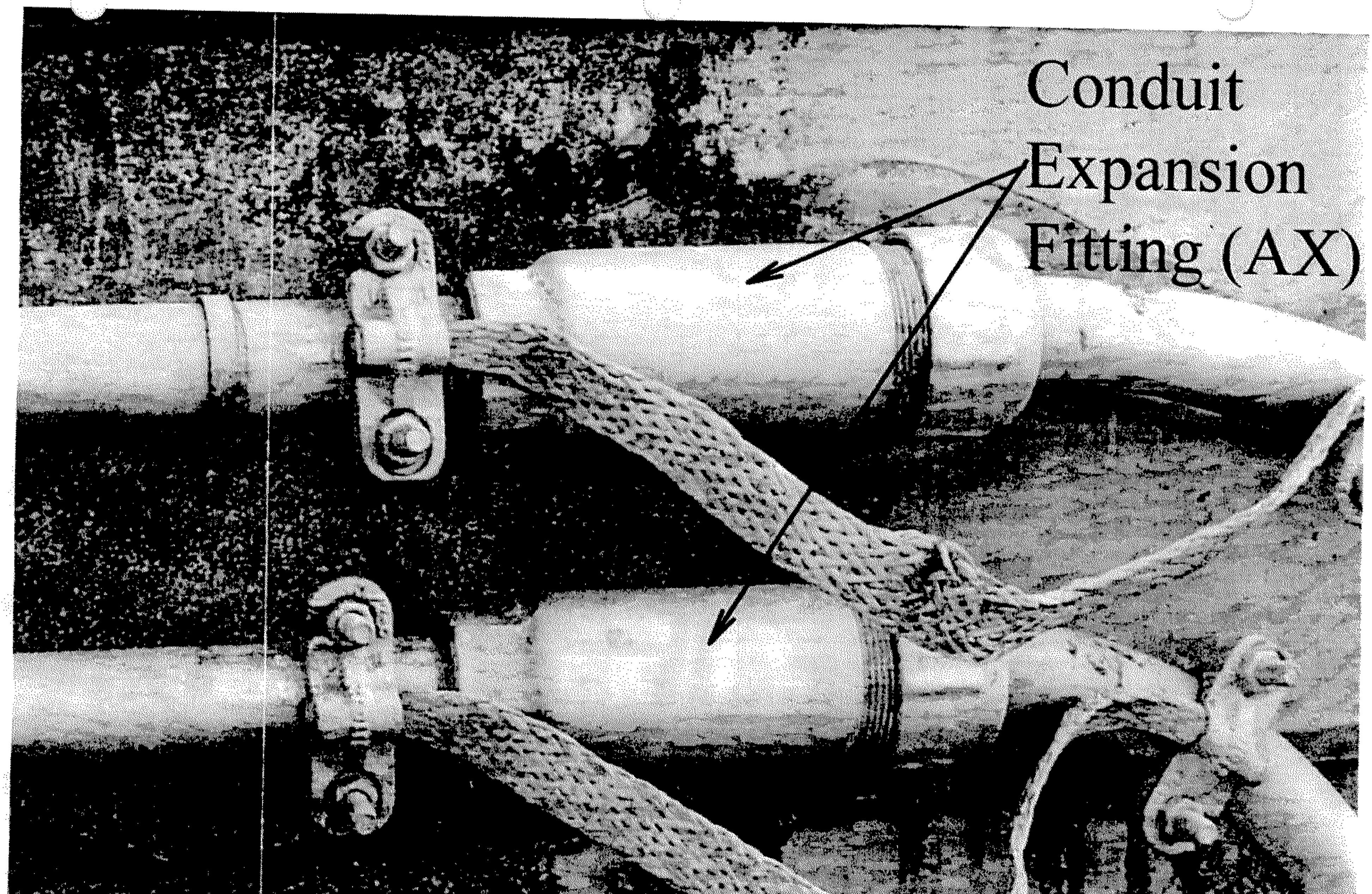
Type AX-8
Provides for 8" Conduit Movement

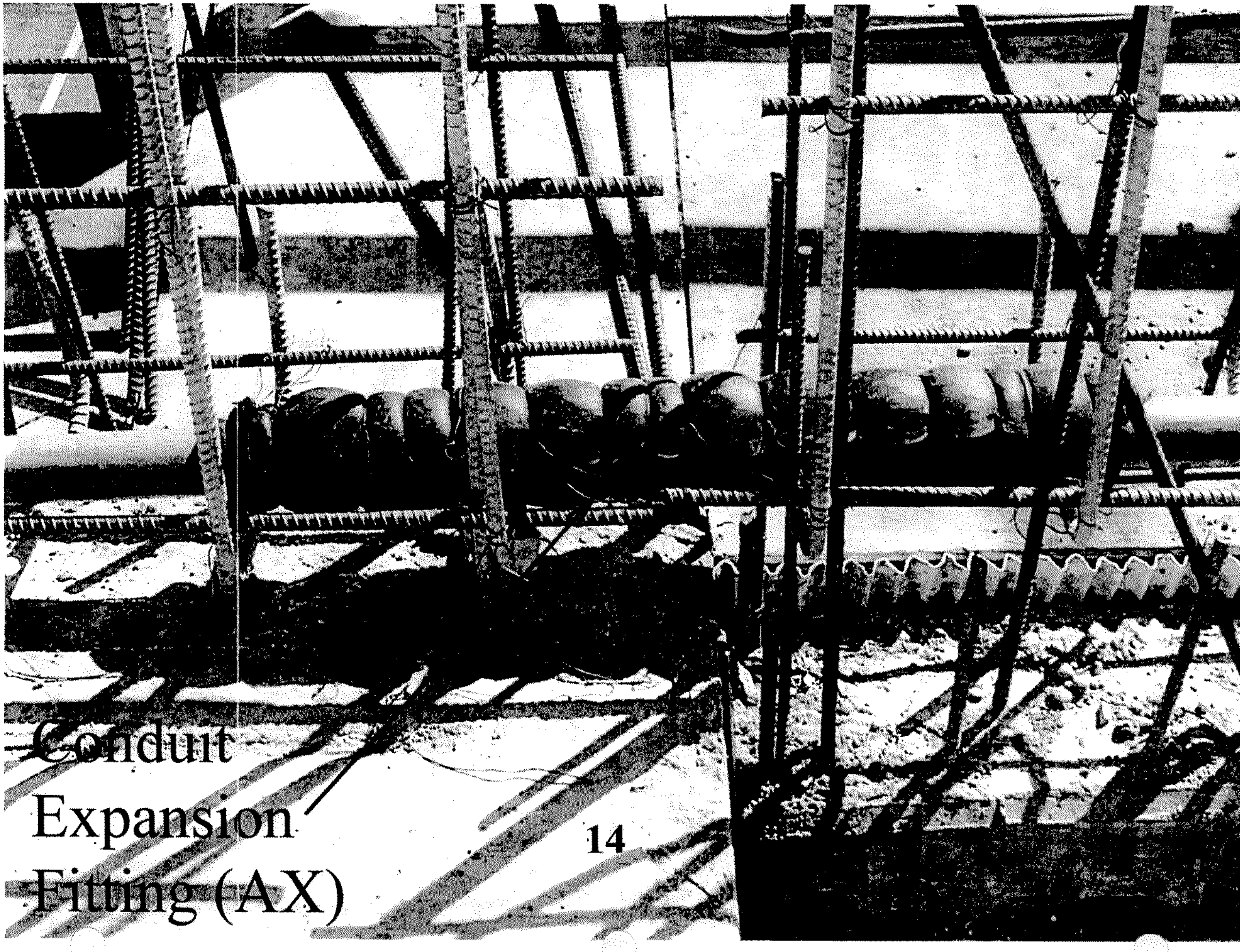


Type AX Provides for 4" Conduit Movement

Bonding Jumper—14"

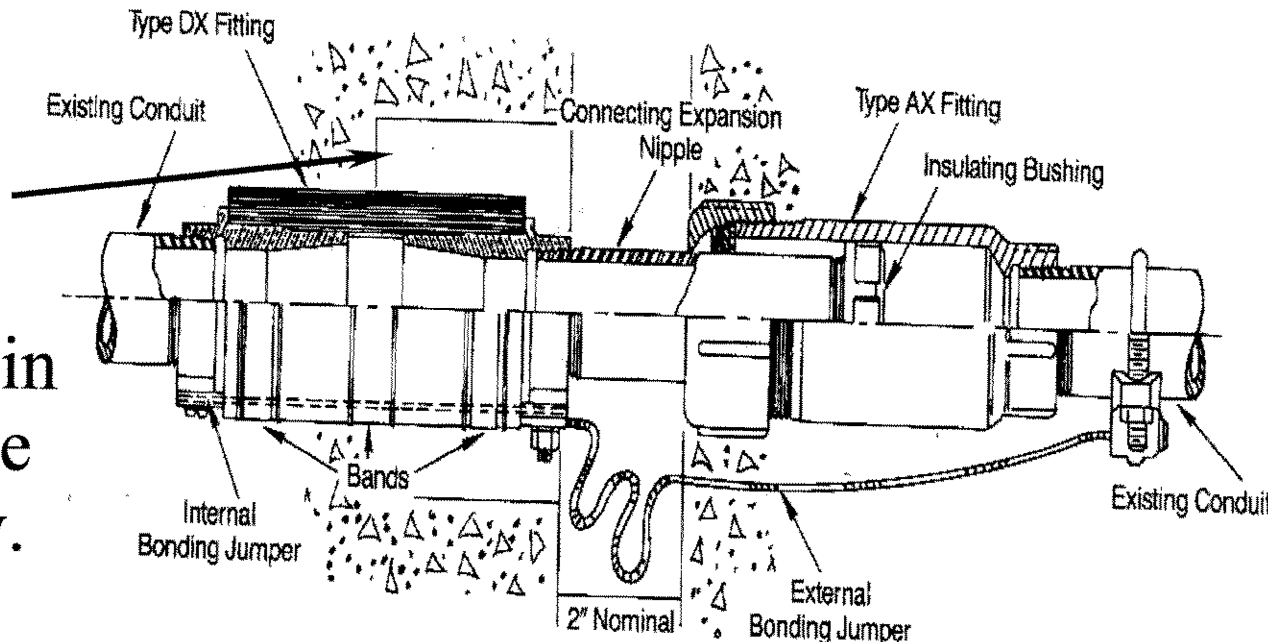
An Expansion Fitting (AX) allows for 4 inches of conduit movement - 2 inches in either direction normal to the conduit.


Conduit
Expansion
Fitting (AX)


Conduit
Expansion
Fitting (AX)

Expansion / Deflection fitting - AX/DX

<u>Note:</u> the blockout cast for the deflection fitting is cast in one side of the structure only.

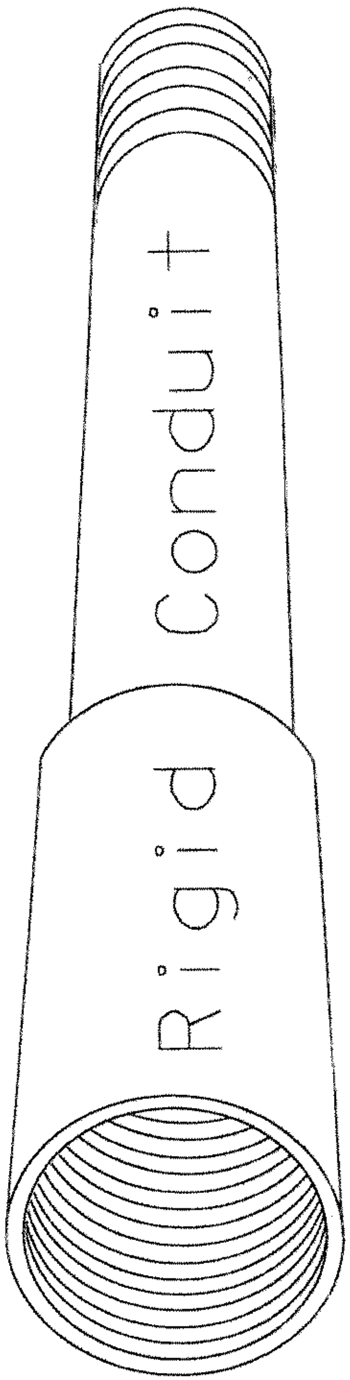


Expansion / Deflection fitting allows for 3/4 inch of expansion or contraction and 30 degrees of bend in any direction and allows for 4 inches of conduit movement - 2 inches in either direction normal to the conduit. Total expansion or contraction is 2 3/4".

Rigid Metal Conduit

- conduit is sized using nominal trade size.
- see table table 4, chapter 9 NEC - 2002 for listed inside diameter of Rigid Metal Conduit,

  PVC Schedule 40 & PVC Schedule 80.
- see ASTM table X2.2, A 53 (STD size) for outside diameter of RMC (or see any supplier catalog).
- American National Standards Institute (ANSI) C80.1 – 1990 for Rigid Steel Conduit – Zinc Coated



Nominal or trade size of conduit in	Customary inch-pound units				
	Nominal inside diameter in	Outside diameter in	Nominal wall thickness in	Length without coupling ft and in	Minimum weight of ten unit lengths with couplings attached lb
3/8	0.493	0.675	0.091	9'11 -1/2"	51.5
1/2	0.632	0.840	0.104	9'11 -1/4"	79.0
3/4	0.836	1.050	0.107	9'11 -1/4"	105.0
1	1.063	1.315	0.126	9'11"	153.0
1 -1/4	1.394	1.660	0.133	9'11"	201.0
1 -1/2	1.624	1.900	0.138	9'11"	249.0
2	2.083	2.375	0.146	9'11"	332.0
2 -1/2	2.489	2.875	0.193	9'10 -1/2"	527.0
3	3.090	3.500	0.205	9'10 -1/2"	682.6
3 -1/2	3.570	4.000	0.215	9'10 -1/4"	831.0
4	4.050	4.500	0.225	9'10 -1/4"	972.3
5	5.073	5.563	0.245	9'10"	1313.6
6	6.093	6.625	0.266	9'10"	1745.3

NOTE –Applicable tolerances:

Length: ± 1/4 in (± 6.35 mm) (without coupling)

Outside diameter
for trade sizes 3/8 in through 2 in: ± 0.015 in (± 0.38 mm)
for trade sizes 2-1/2 in through 4 in: ± 0.025 in (± 0.64 mm)
for trade sizes 5 and 6 in: ±1%

Wall thickness: See 7.3.

American National Standards Institute (ANSI) C80.1 – 1990 for Rigid Steel Conduit – Zinc Coated

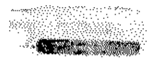
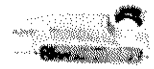
Conduit Bodies (condulets)

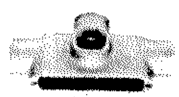
- There are different types for use with each type conduit.
- WSDOT uses Rigid Metal Conduit.
- These conduit bodies are for use with both types.
- IMC is abbreviation for Intermediate metal conduit - not allowed for use in our specification.
- there are other types - see any conduit supply catalog for specifics if other type needed.
- our plans would usually only call out for a "condulet", not a specific Type i.e.: "LB".

Form 35® Malleable Iron Unilet® Conduit Outlet Bodies

Threaded Type for use with Rigid Metal Conduit and IMC;
Compression Type for use with Threadless Rigid Metal Conduit.

Appleton Form 35® Threaded Type Conduit Bodies NOTE: Refer to page A-16 for Wiring Capacity Tables

Hub Size (in.)	C	E	LB	LL	LR
					
1/2	C50-M	E50-M	LB50-M	LL50-M	LR50-M
3/4	C75-M	E75-M	LB75-M	LL75-M	LR75-M
1	C100-M	E100-M	LB100-M	LL100-M	LR100-M
1-1/4	C125-M◊	E125-M	LB125-M◊	LL125-M	LR125-M
1-1/2	C150-M◊	E150-M	LB150-M◊	LL150-M	LR150-M
2	C200-M◊	—	LB200-M◊	LL200-M	LR200-M
2-1/2	C250-M◊	—	LB250-M◊	LL250-M	LR250-M
3	C300-M◊	—	LB300-M◊	LL300-M	LR300-M
3-1/2	C350-M◊	—	LB350-M◊	LL350-M	LR350-M
4	C400-M◊	—	LB400-M◊	LL400-M	LR400-M
5	—	—	LB500-M	—	—
6	—	—	LB600-M	—	—

Hub Size (in.)	LRL*	T	TA	TB	X
					
1/2	LRL50-M	T50-M	TA50-M	TB50-M	X50-M
3/4	LRL75-M	T75-M	TA75-M	TB75-M	X75-M
1	LRL100-M	T100-M	TA100-M	TB100-M	X100-M
1-1/4	LRL125-M	T125-M	—	TB125-M	X125-M
1-1/2	LRL150-M	T150-M	—	TB150-M	X150-M
2	LRL200-M	T200-M	—	TB200-M	X200-M
2-1/2	—	T250-M	—	—	—
3	—	T300-M	—	—	—
3-1/2	—	T350-M	—	—	—
4	—	T400-M	—	—	—

*LRL Unilets have double opening and are furnished with one steel cover, assembled.
◊ Catalog numbers having patented roller feature, all others do not.

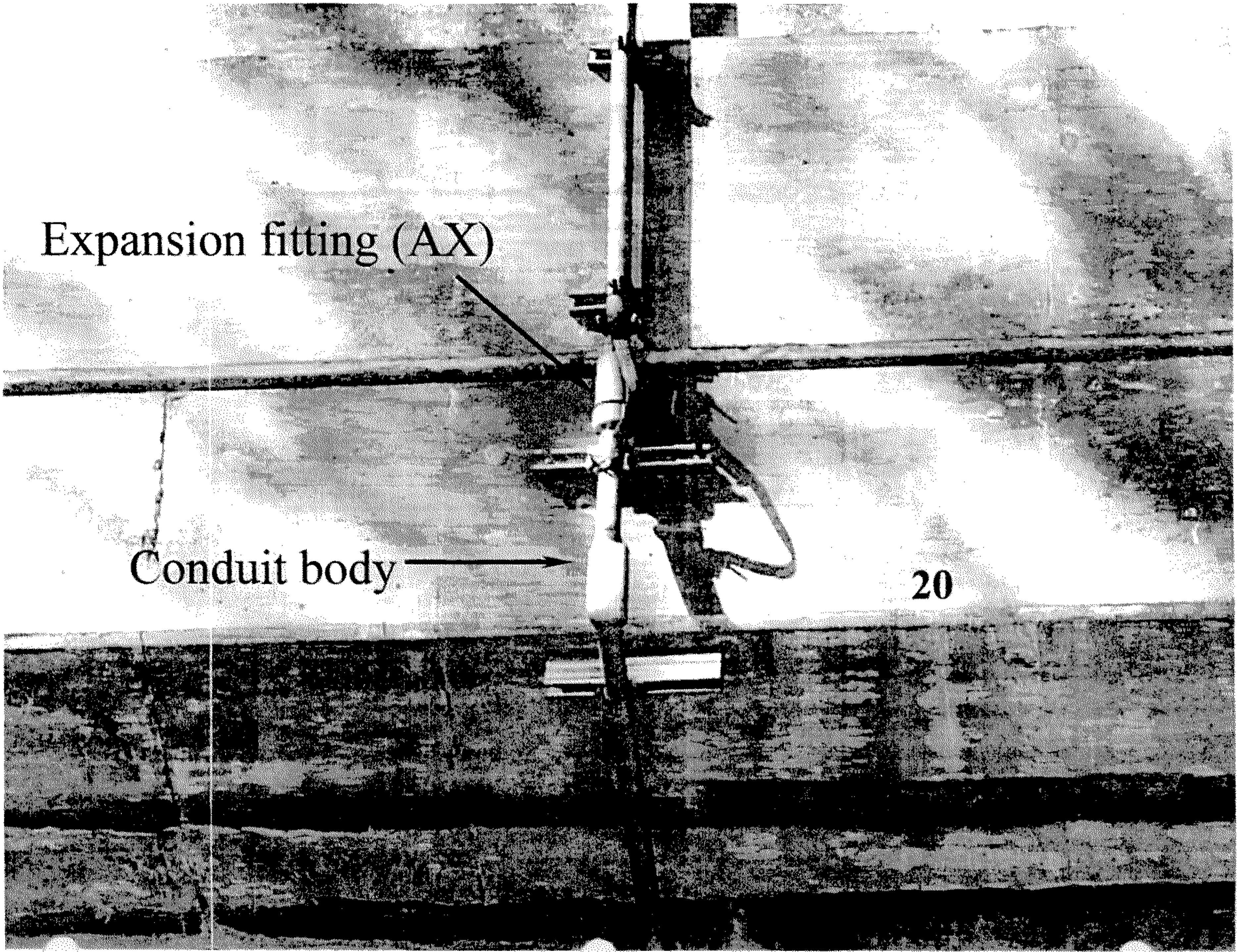
Compression Type—For use with Threadless Rigid Metal Conduit

Hub Size (in.)	LB	LRL*	T
			
1/2	LB50N-M	LRL50N-M	T50N-M
3/4	LB75N-M	LRL75N-M	T75N-M
1	LB100N-M	LRL100N-M	T100N-M

Back Style for Form 35 Unilet conduit body sizes (inches)

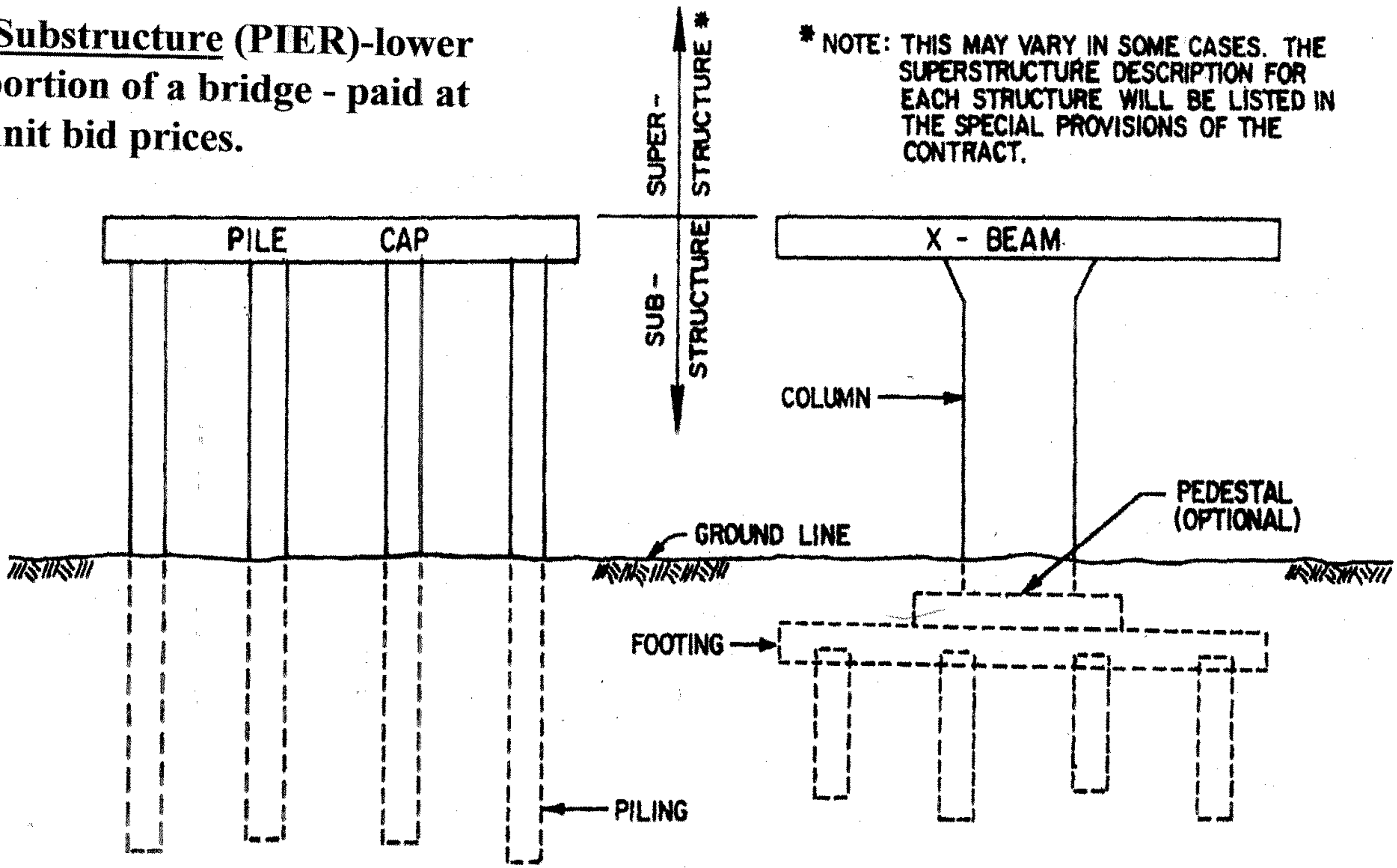
Unilet Body	Flat Back	Round Back
C, LB	1/2 - 2	2-1/2 and up
E	1/2 - 1-1/2	1-1/4 and up
LL, LR, T	1/2 - 2	2-1/2 and up
TB	1-1/4, 1-1/2	1/2, 3/4, 1, 2
X	1/2 - 1	1-1/4 and up

All TA Unilets are round back design.
All Compression Type are flatback design.

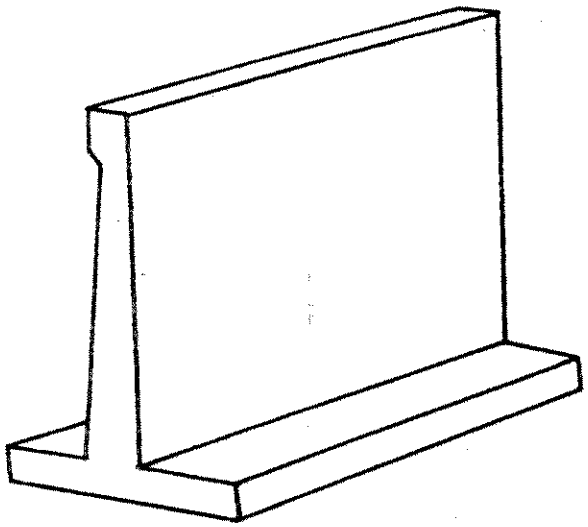

Expansion fitting (AX)
Conduit body
20

Bridge definitions

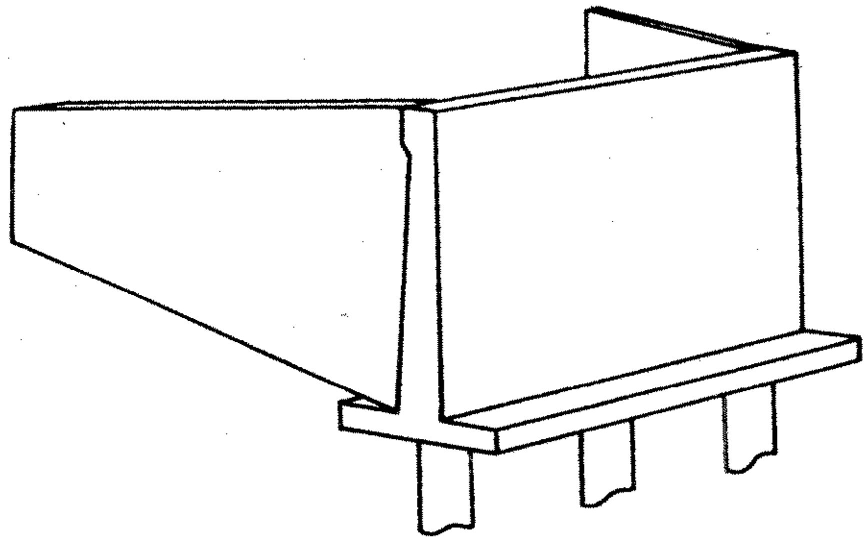
- **Superstructure** - upper portion of a bridge - paid as lump sum.
- **Substructure** (PIER)-lower portion of a bridge - paid at unit bid prices.



Bridge abutments (end pier)



Wall Type Pier

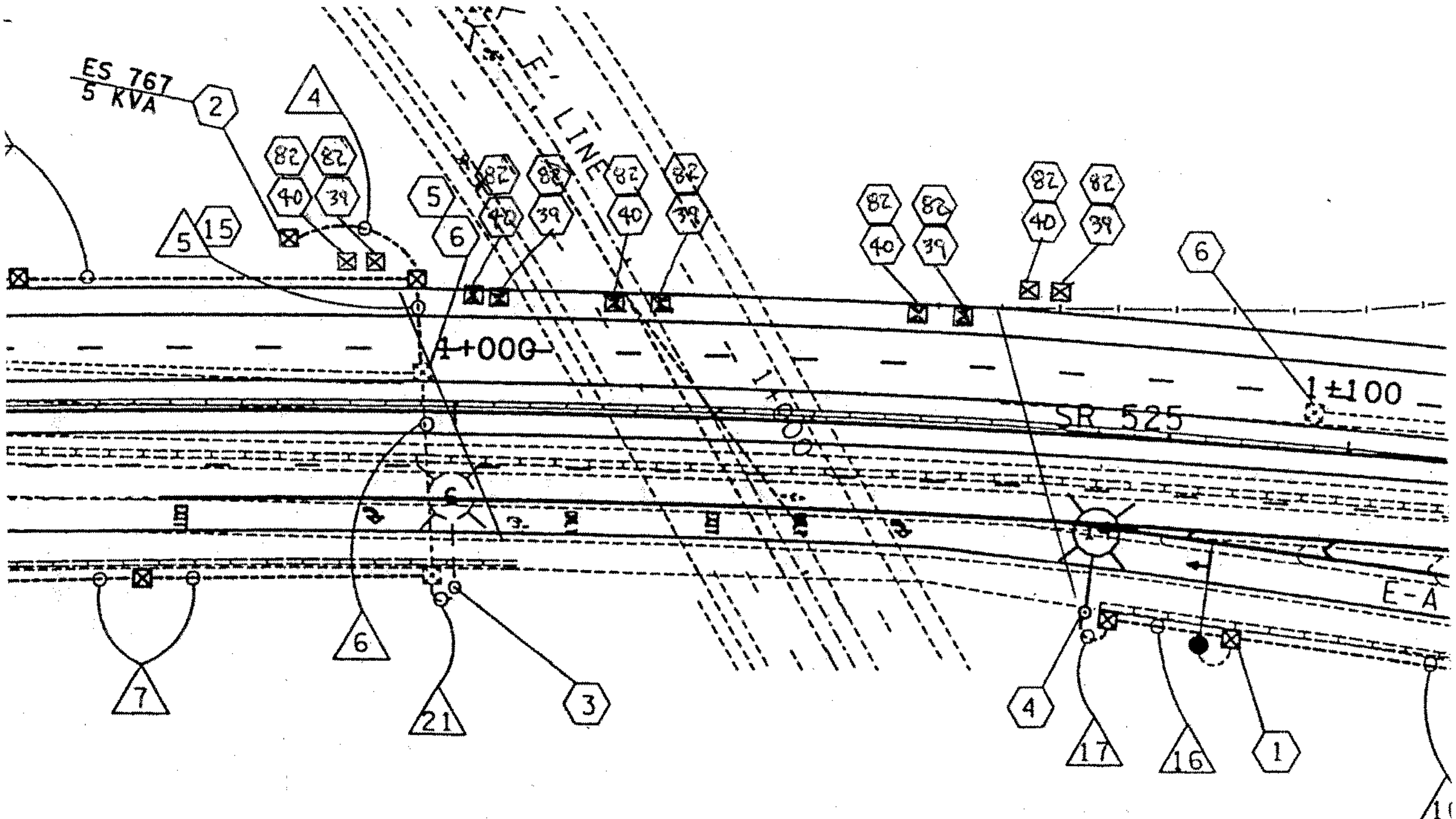


Abutment Pier

The bridge abutments are designed to both support the bridge & contain the earth fill at each end of the bridge. (See contract plans reading course chapter 5 for further discussion of bridge layout and definitions).

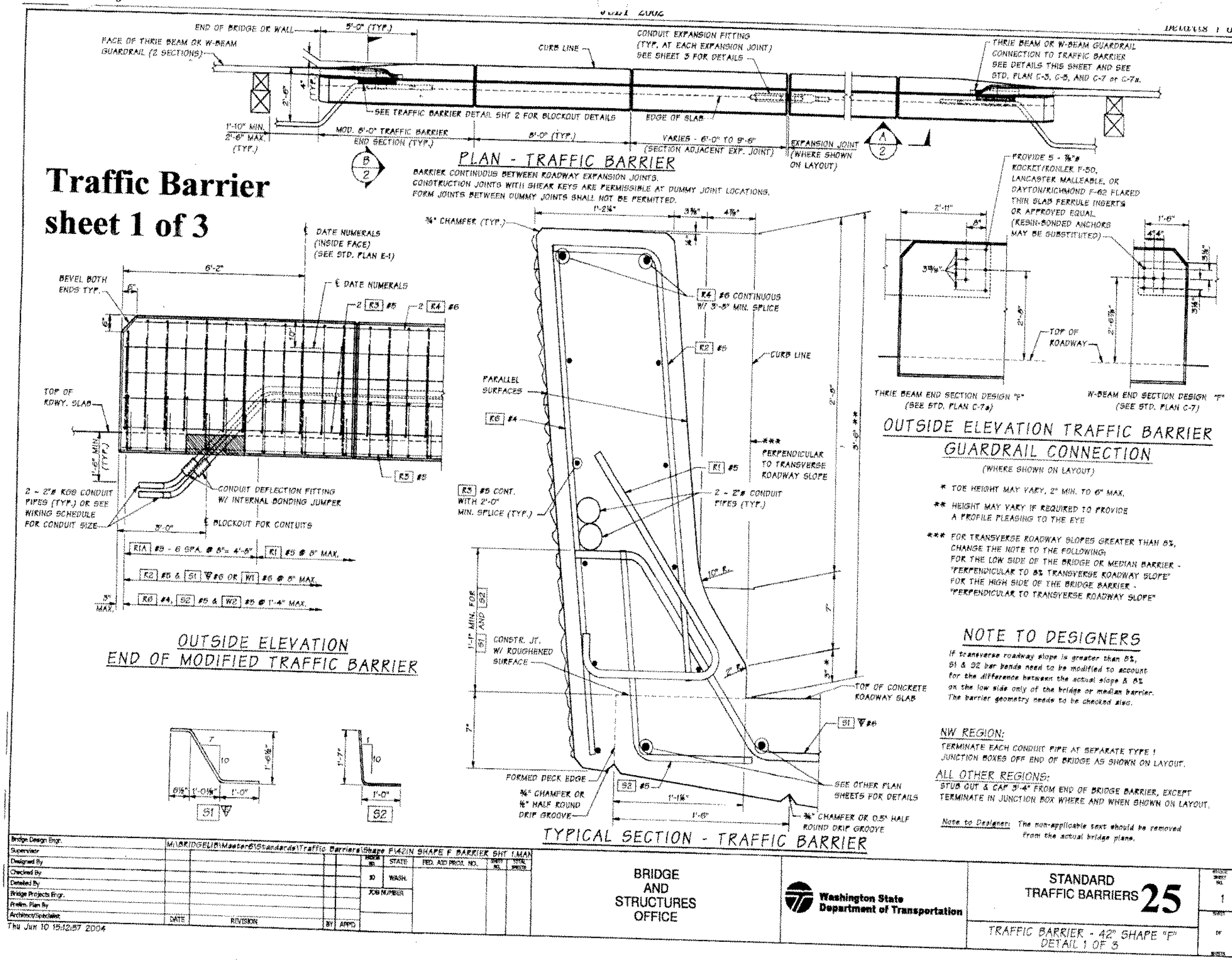
Traffic Design Construction Notes

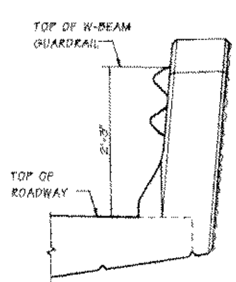
- 39. TS 40. LT 41. COMM 42. ITS(SC&DI)
- 82. General note: Junction box labeling shown for structures only. Label all other junction boxes per standard plan J-11a and special provisions.
- Use these notes on Illumination, Traffic Signal, Power supply or ITS(SC&DI) sheets as required.
- Use notes only on sheets that have conduit passing through structure.
- The intention of these notes is to define how you want to label the junction boxes across the structure.



Example of how to label illumination plan sheet that details conduits crossing structure & labeling of junction boxes on structure and in grade off structure

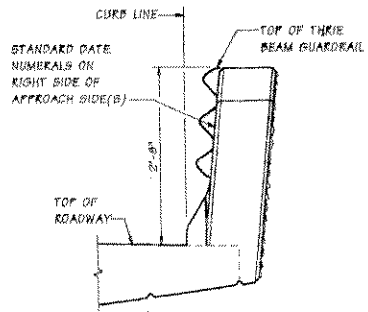
Traffic Barrier sheet 1 of 3





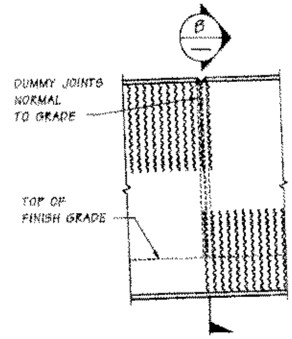
END VIEW

W-BEAM SHOWN WITH "D" CONNECTION



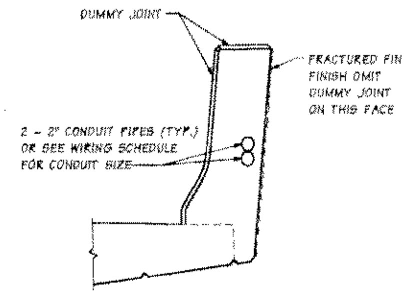
END VIEW

THRIE BEAM SHOWN WITH "D" CONNECTION

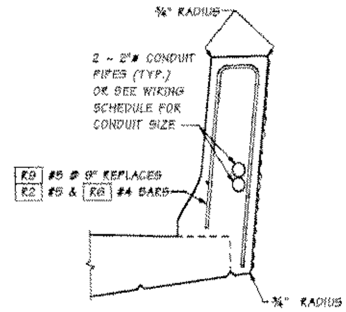


VIEW (A/1)

ALL CHAMFERS ¾"



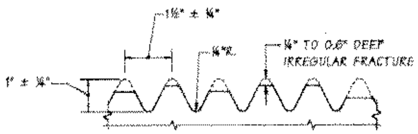
SECTION (B)



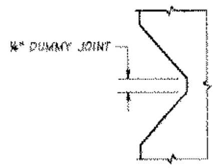
SLIPFORM ALTERNATE

SEE "TYPICAL SECTION - TRAFFIC BARRIER" FOR ADDITIONAL DETAILS

THE CONTRACTOR IS ADVISED THAT THE SLIPFORM CONSTRUCTION METHOD IS A PATENTED PROPRIETARY PROCESS FOR BARRIERS WITH A FRACTURED FIN FINISH.



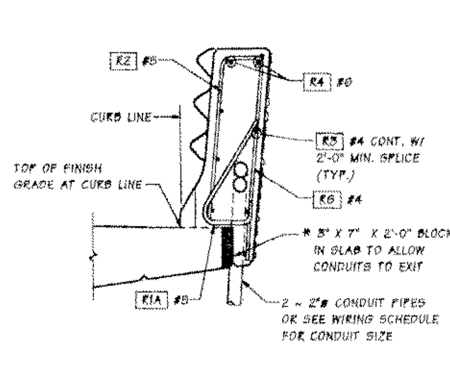
FRACTURED FIN FINISH



DUMMY JOINT DETAIL

Traffic Barrier sheet 2 of 3

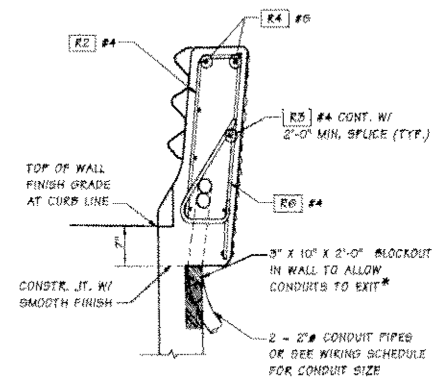
JUNCTION BOX LOCATIONS	
STATION	OFFSET



SECTION (B/?) BRIDGE

FOR DETAILS NOT SHOWN SEE "OUTSIDE ELEVATION" AND "TYPICAL SECTION - TRAFFIC BARRIER"

* BLOCKOUT WIDTH MAY BE INCREASED TO 6" TO ALLOW CONDUITS OF A LARGER DIAMETER THAN 2" TO EXIT BARRIER OR WALL WITHOUT REBAR STEEL CONFLICT



SECTION (B/?) WALL

DETAIL FOR RETAINING WALL OR WINGWALL. FOR REINFORCING NOT SHOWN SEE STD. PLAN D-1a & D-1b OR WINGWALL PLAN. FOR DETAILS NOT SHOWN SEE SECTION (B) BRIDGE

TRAFFIC BARRIER BAR LIST

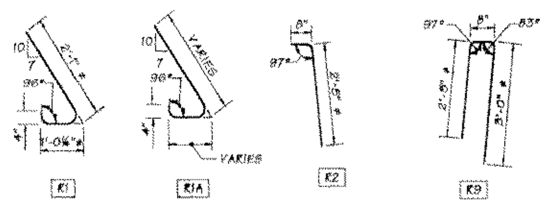
ALL REINFORCING SHALL BE AASHTO M31, GR. 60.

MARK	SIZE	LENGTH	
R1	5	3'-8"	
R1A	5	(A)	
R2	5	2'-11"	
R3	4	(A)	STR.
R4	6	(A)	STR.
R6	4	3'-0"	STR.
R9	5	5'-11"	

(A) DETERMINE FROM PLANS

BENDING DIAGRAM (ALL DIMENSIONS ARE OUT TO OUT)

* DIMENSIONS TO POINTS OF INTERSECTION



FOR W1 ∇ & W2 BARS SEE WINGWALL OR RETAINING WALL PLANS.
FOR S1 ∇ & S2 BARS SEE BARLIST

Bridge Design Engr.	M:\BRIDGELIB\MasterB\Standards\Traffic Barriers\Shape F\SHAPE F BARRIER SHT 2.man							
Supervisor				REGION NO.	STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
Designed By				10	WASH.			
Checked By				JOB NUMBER				
Detailed By								
Bridge Projects Engr.								
Prelim. Plan By								
Architect/Specialist	DATE	REVISION	BY	APP'D				

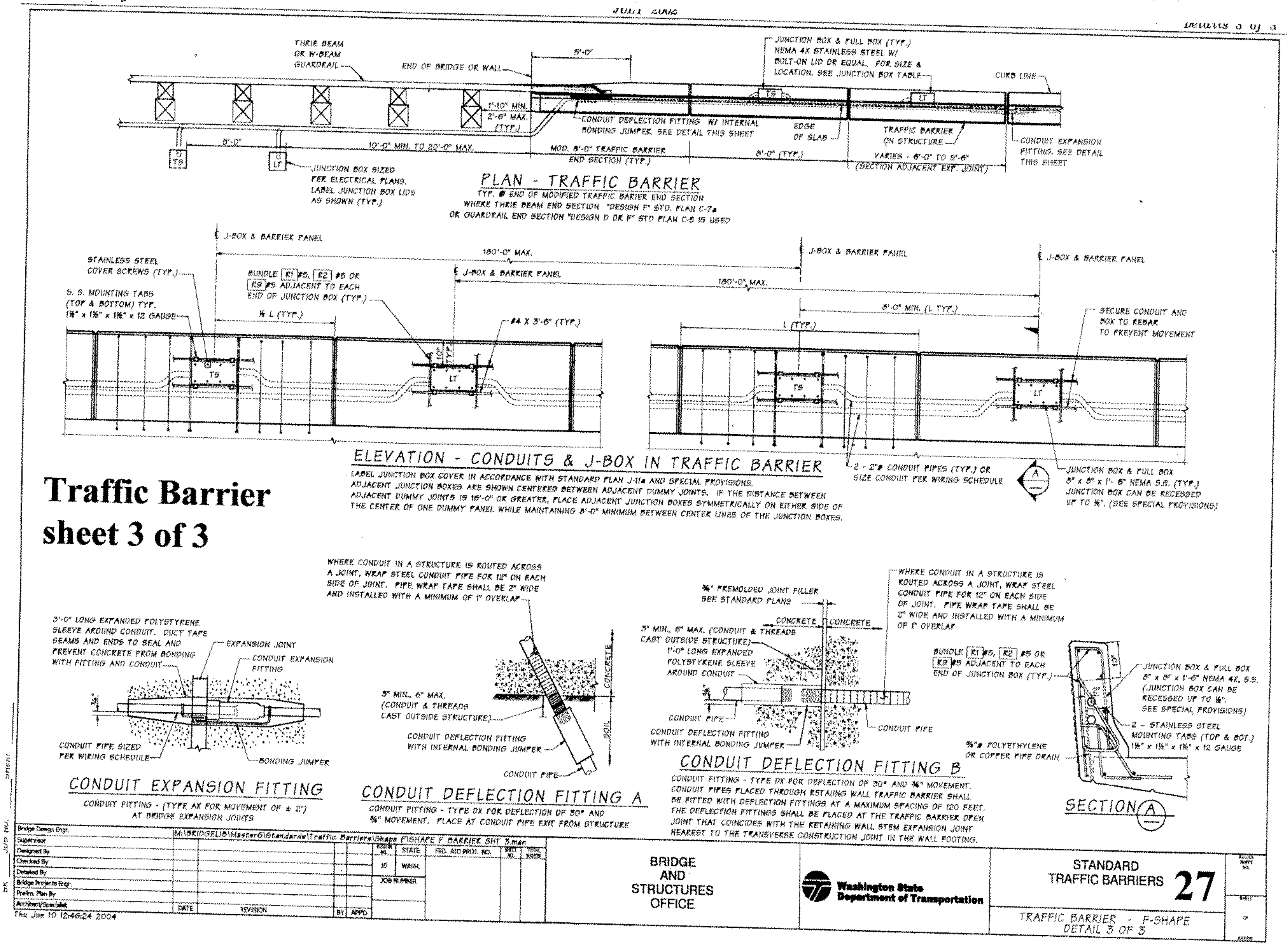
BRIDGE AND STRUCTURES OFFICE

Washington State Department of Transportation

STANDARD TRAFFIC BARRIERS 26

TRAFFIC BARRIER - F-SHAPE DETAIL 2 OF 3

Traffic Barrier sheet 3 of 3



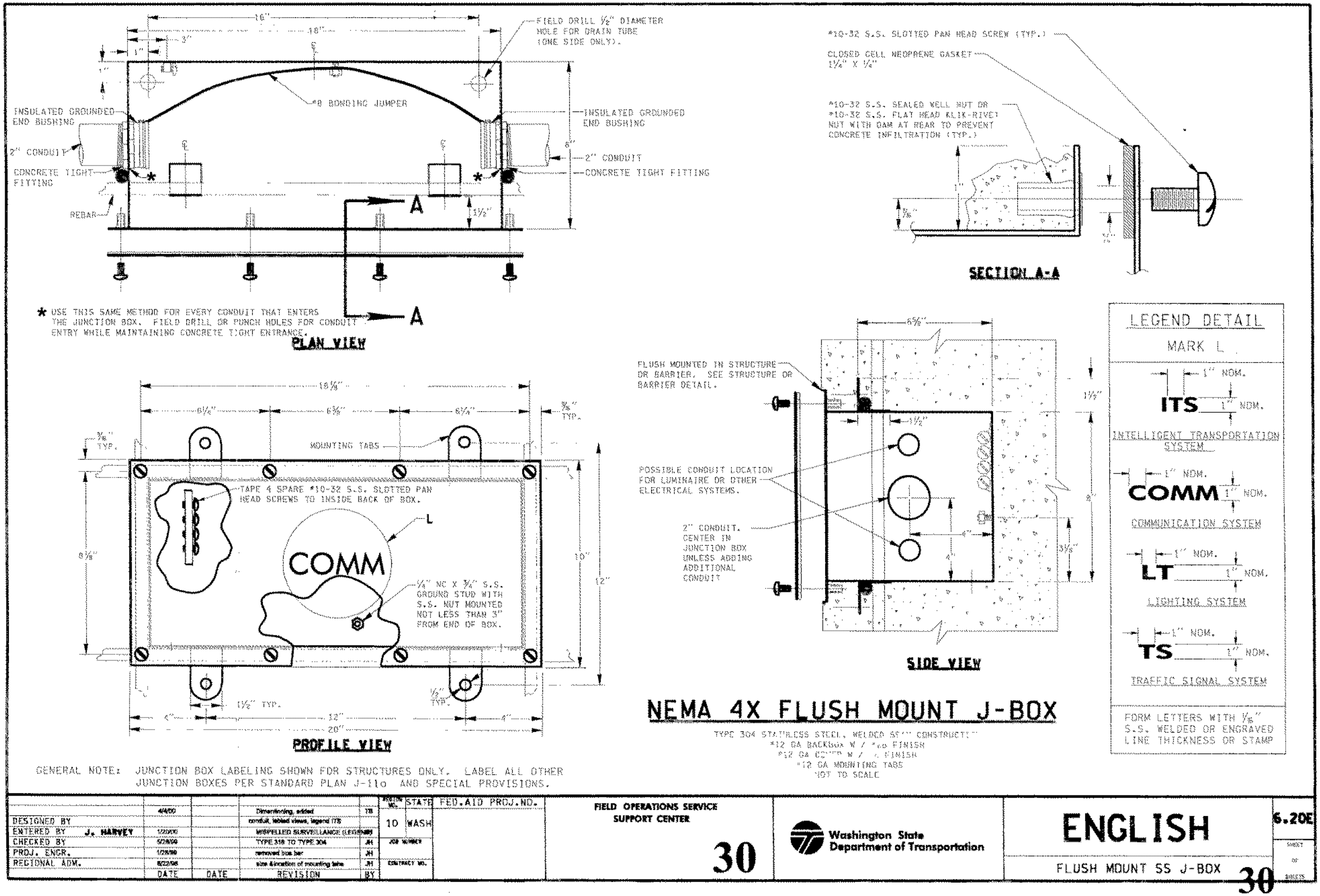
Special Provisions

- Junction Boxes - Section 8-20.3(6) is supplemented with the following:
- Where conduit and junction boxes are placed in barrier, the prime Contractor shall coordinate the work of the Contractor constructing the barrier and the electrical Contractor so that each junction box placed in the barrier is placed in correct alignment with respect to the barrier, with the face of the box flush. The junction box shall be parallel to the top of the barrier within a 1-degree tolerance. If any point on the face of a junction box placed in barrier is recessed more than 1/8 inch from the surface of the barrier, the Contractor shall install a box extension per the Engineer's approval and grout around the extension or remove and replace the entire section of barrier.

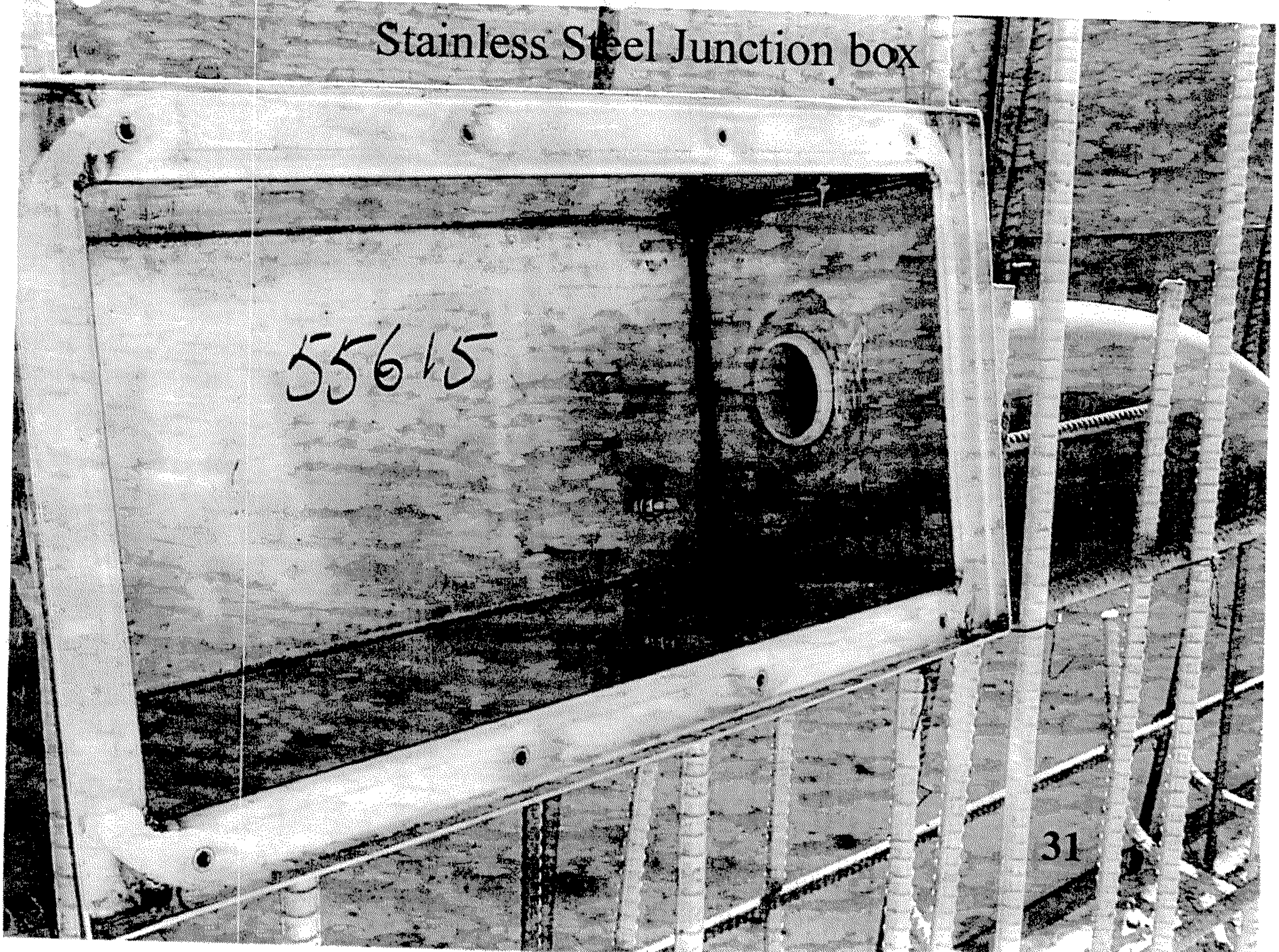
Special Provisions

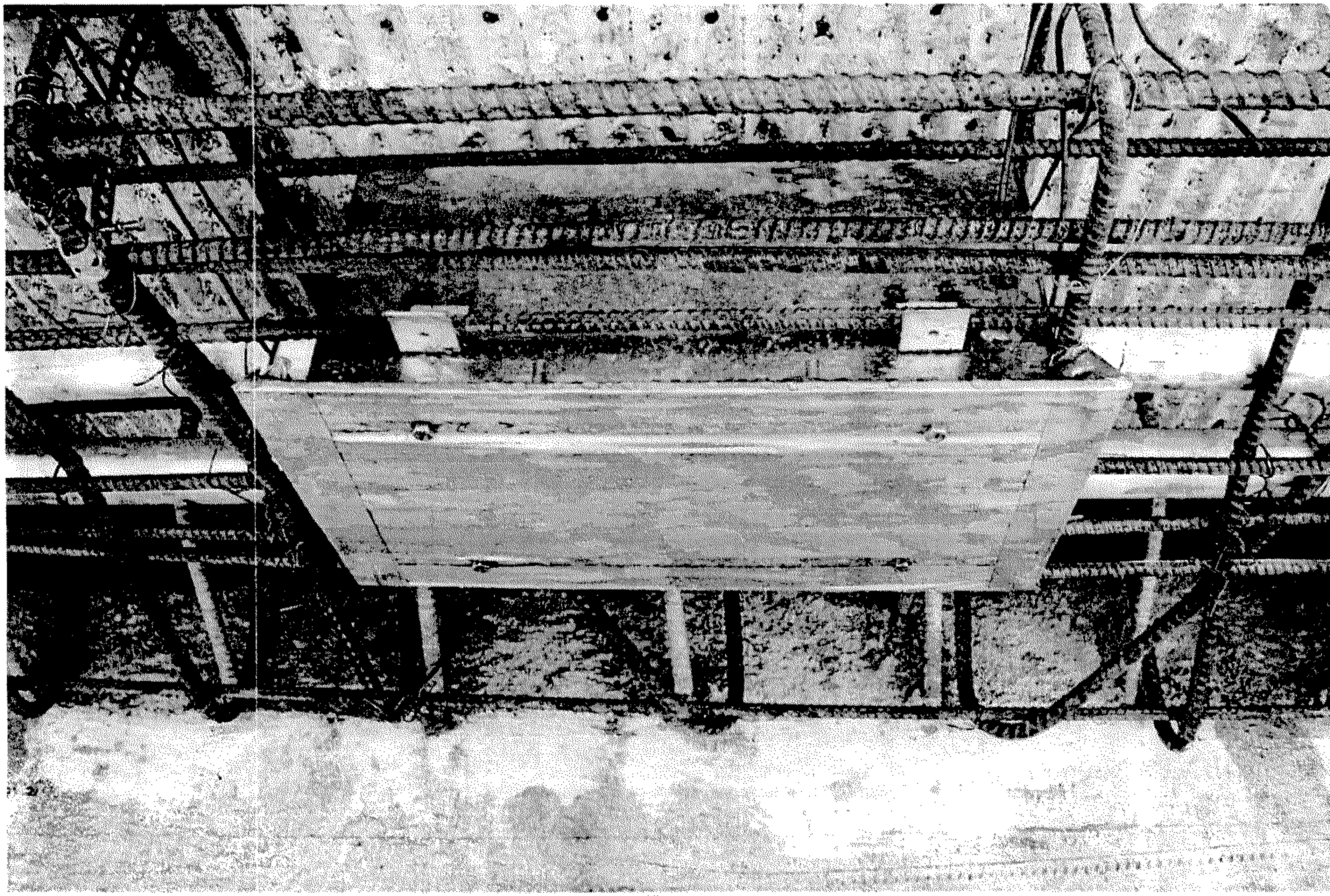
- Section 9-29.2 is supplemented with the following:
- **NEMA Stainless Steel Junction Boxes**
- NEMA stainless steel junction boxes and cover screws shall conform to ASTM A 304. Junction boxes installed on exterior of structures shall have an external hinge. Junction boxes shall be labeled with the appropriate designation. See Standard Plans for traffic signal system and illumination system labeling. Communication system boxes shall be labeled in the same manner, with the exception that the label shall be COMM.
- Polyethylene drain tubes for junction boxes mounted in structures shall be 3/8-inch diameter with a wall thickness of 0.062 inches and shall be rated for a 110 psi working pressure at 73° F.
- Surface mounted junction boxes and junction boxes placed in cast in place structures shall be NEMA 4X.
- Junction boxes installed in structures constructed by slip forming shall be NEMA 3X and shall be adjustable for depth, with depth adjustment bolts, which are accessible from the front face of the junction box with the lid installed.

Stainless Steel Junction box

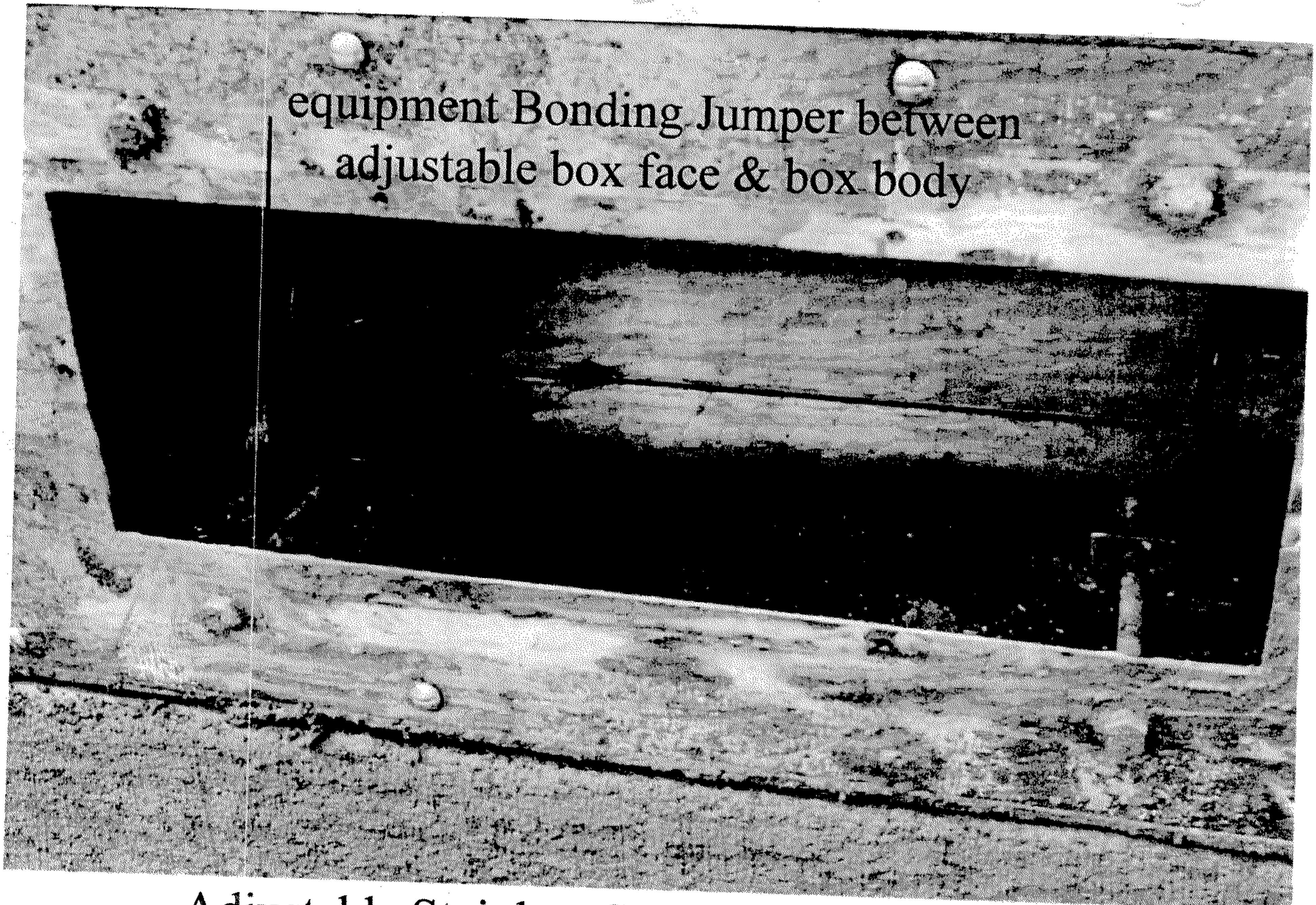


Stainless Steel Junction box



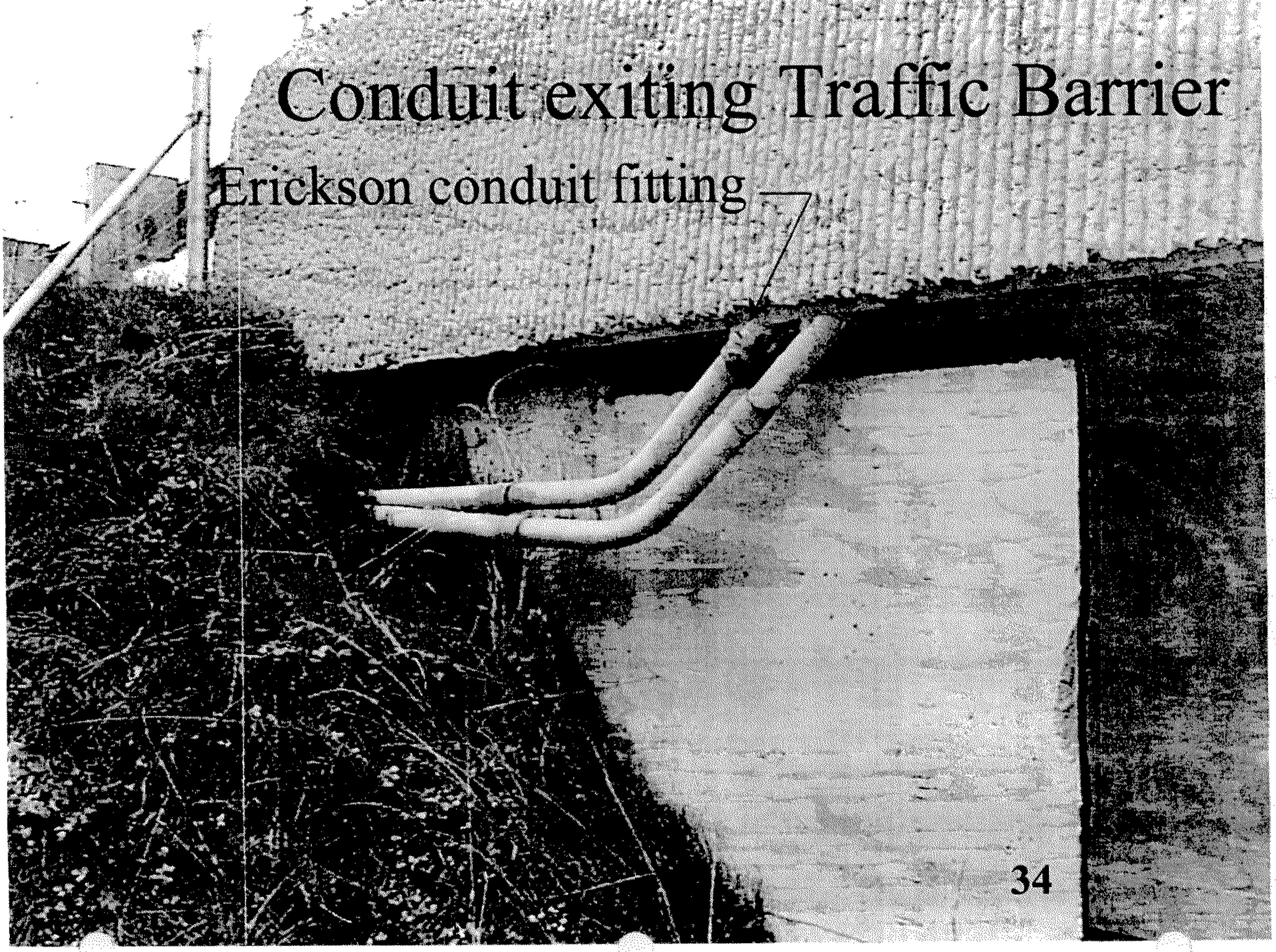


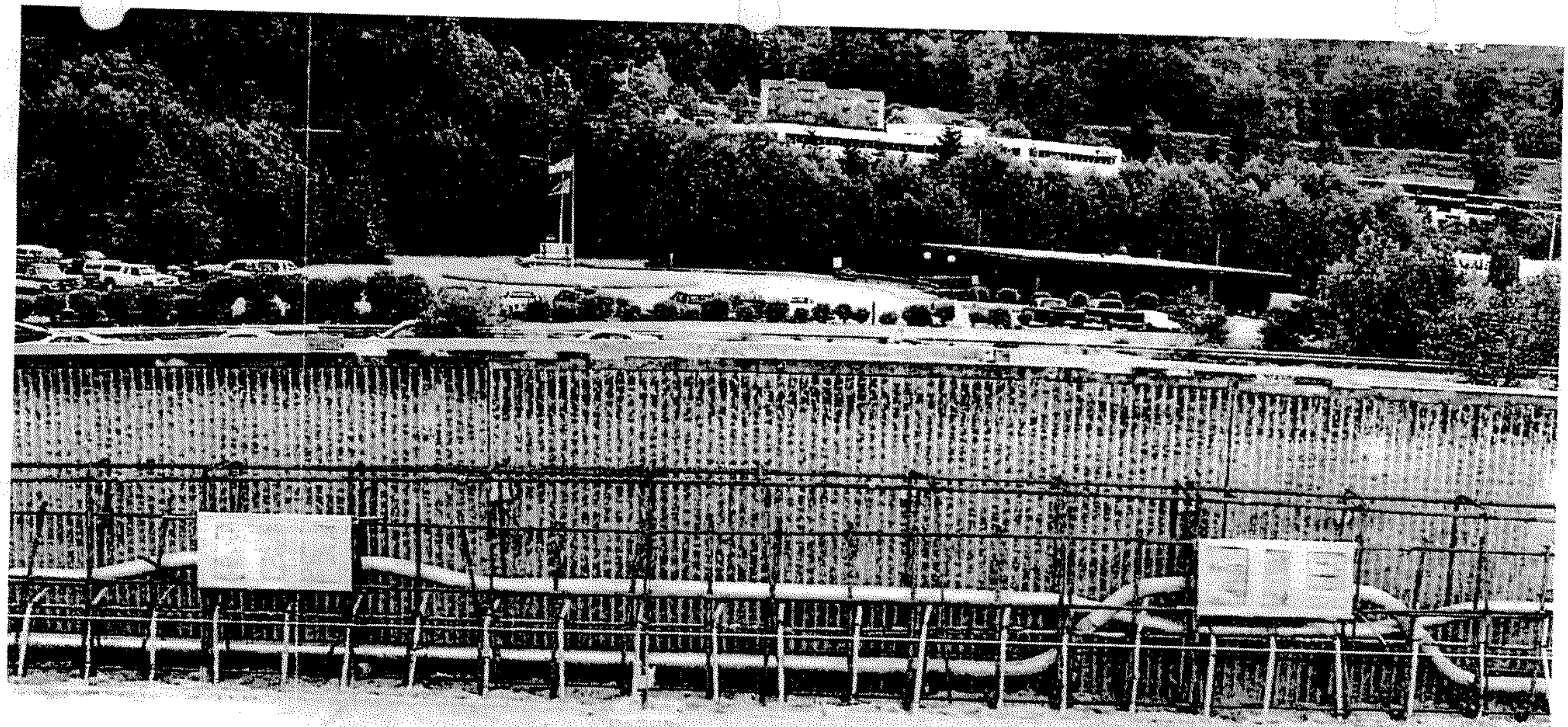
Adjustable Stainless Steel Junction box



Adjustable Stainless Steel Junction box

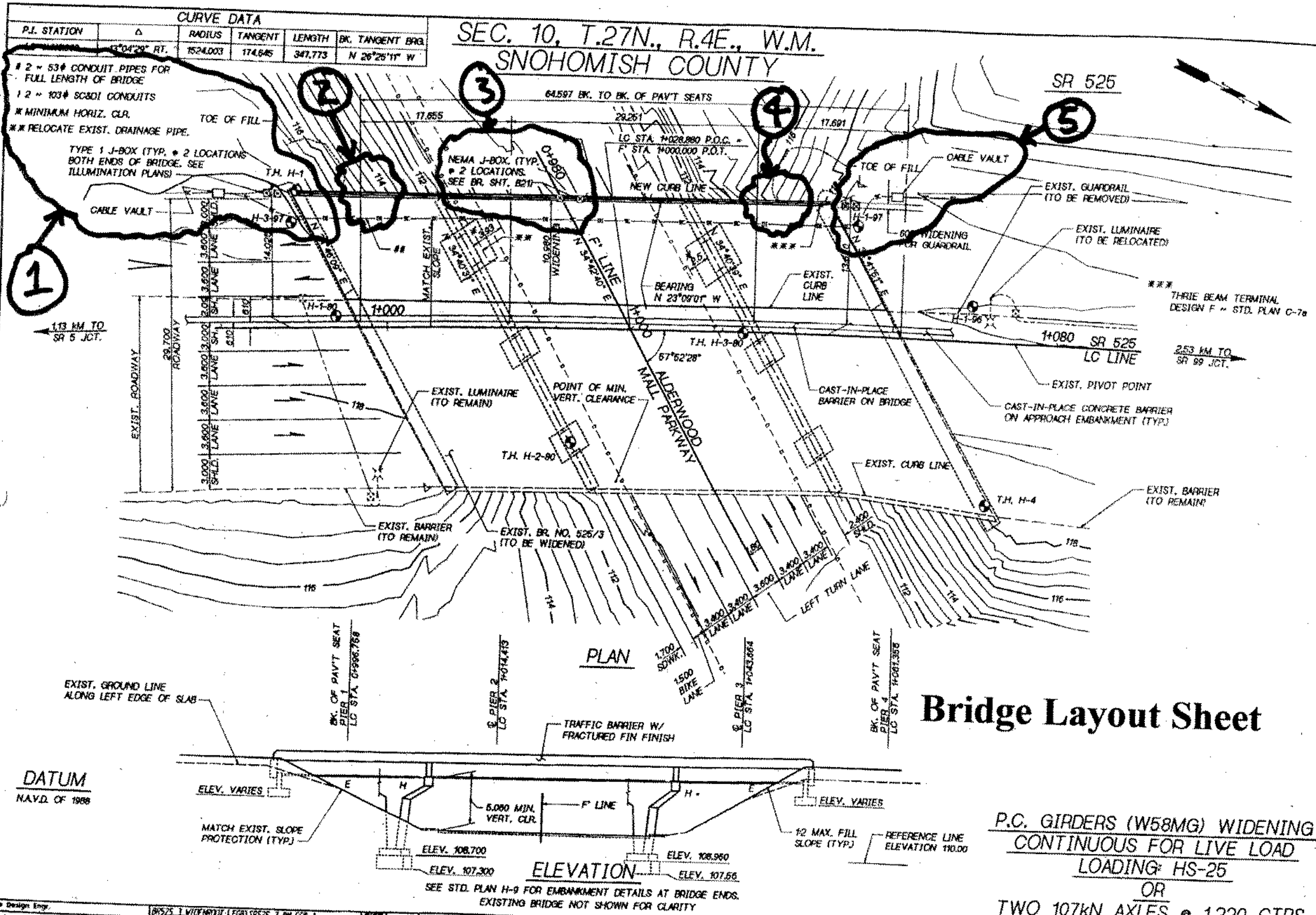
Conduit exiting Traffic Barrier






FOR
39173-Z

Bridge Layout Sheet



P.C. GIRDERS (W58MG) WIDENING
CONTINUOUS FOR LIVE LOAD
LOADING: HS-25
OR
TWO 107kN AXLES @ 1.220 CTRS.

Designed By	M. WOO 2/97
Checked By	R. G. BRAMMEYER 11/96
Detailed By	G. A. T. WALDRON 11/96
Bridge Projects Engr.	
Prelim. Plan By	H. ZHANG 11/96
Architect/Specialist	A. YOUNG 11/96

10 WASH.

BRIDGE AND STRUCTURES OFFICE

Washington State Department of Transportation

SR525 I-5 to SR99
OL-1610
37
SCDIBRIDGE1

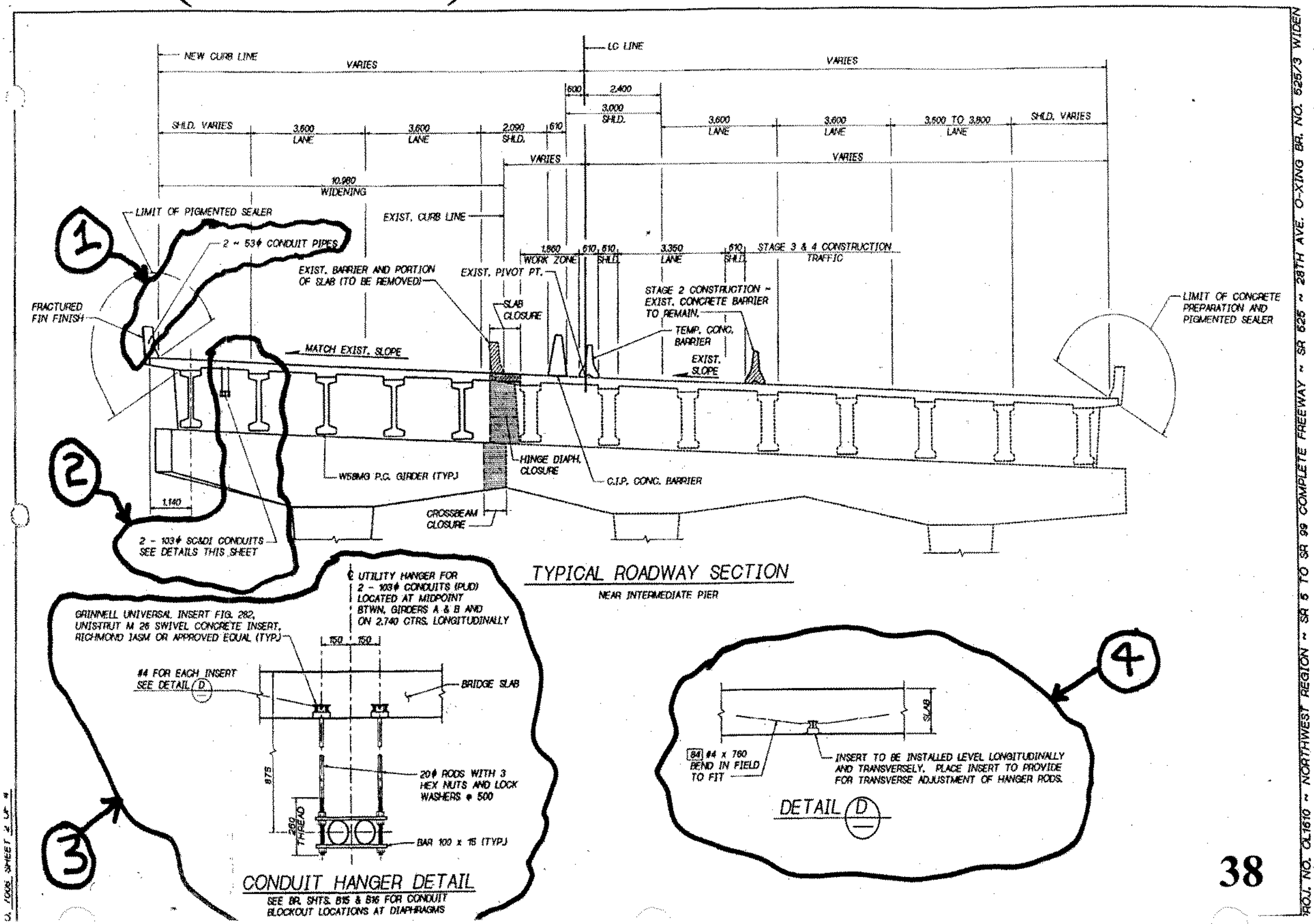
B2
345
412

PLAN AND ELEVATION

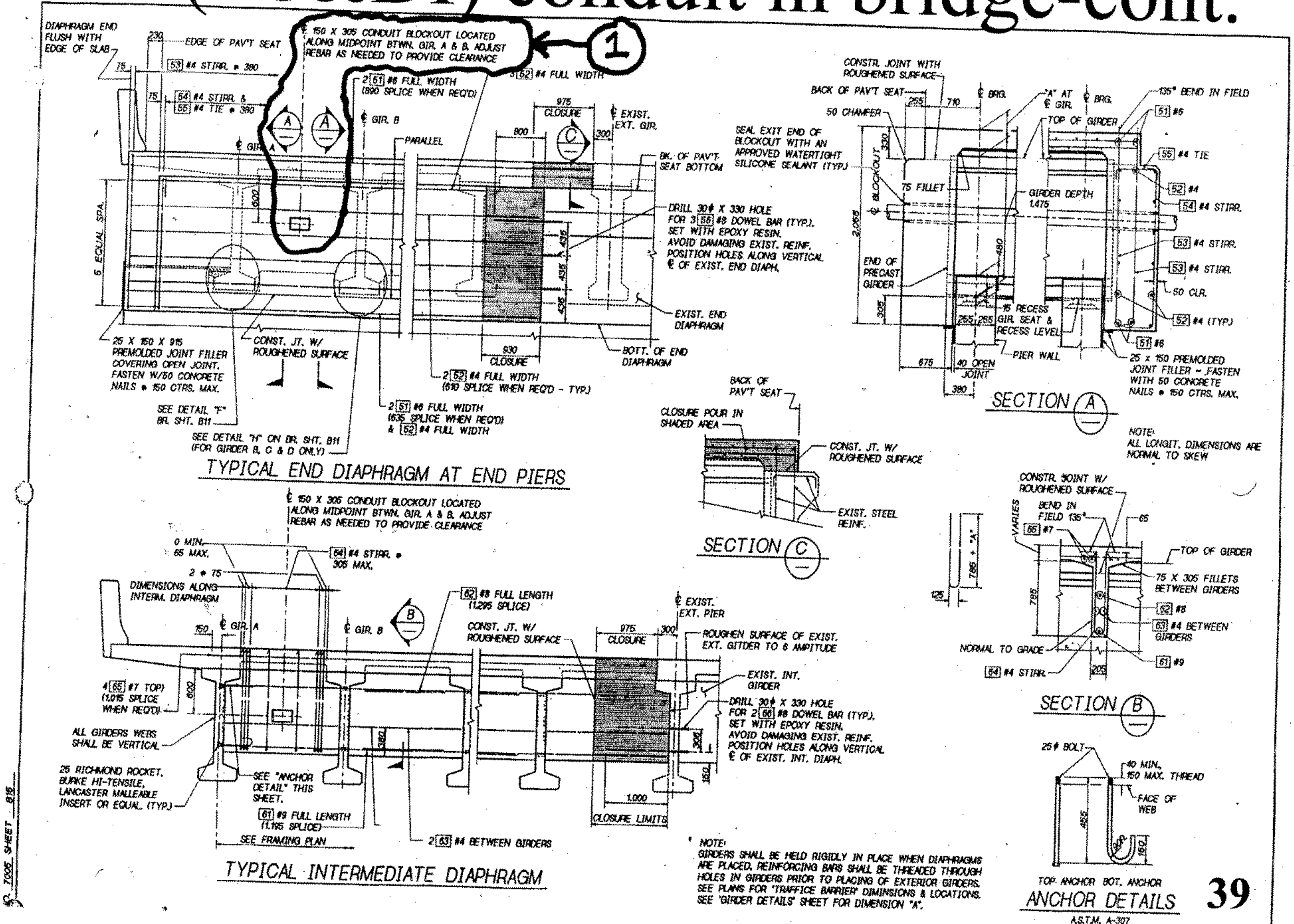
SR 525 JOB NO. 7006 SHEET 1 OF 4

C.S. 3127 ~ PROJ. NO. OL1610 ~ NORTHWEST REGION ~ SR 5 TO SR 99 COMPLETE FREEWAY ~ SR 525 ~ 28TH AVE. O-XING BR. NO. 525/3 WIDEN

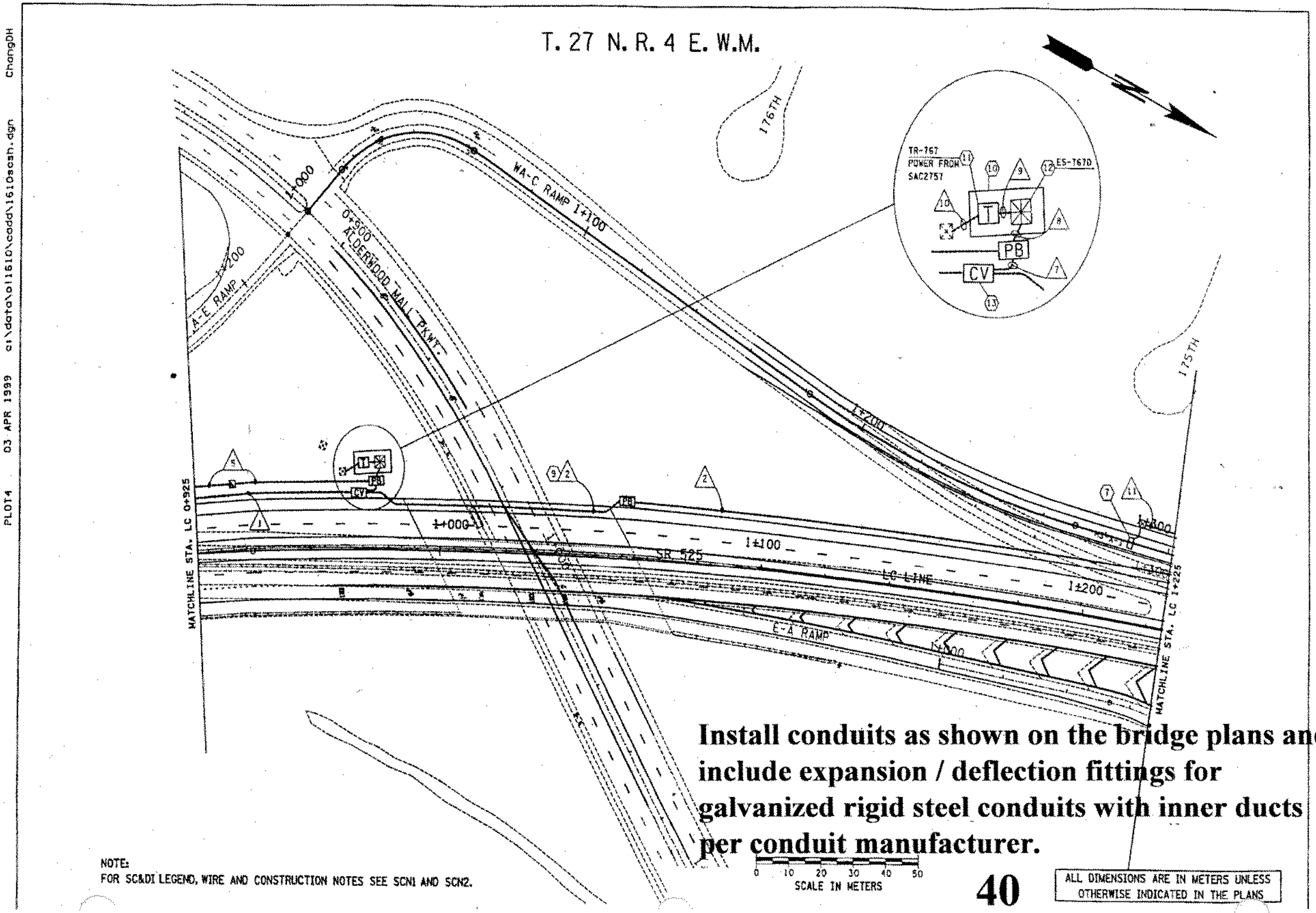
ITS(SC&DI) - install conduit details



ITS(SC&DI) conduit in bridge-cont.



ITS(SC&DI) conduit in bridge-cont.

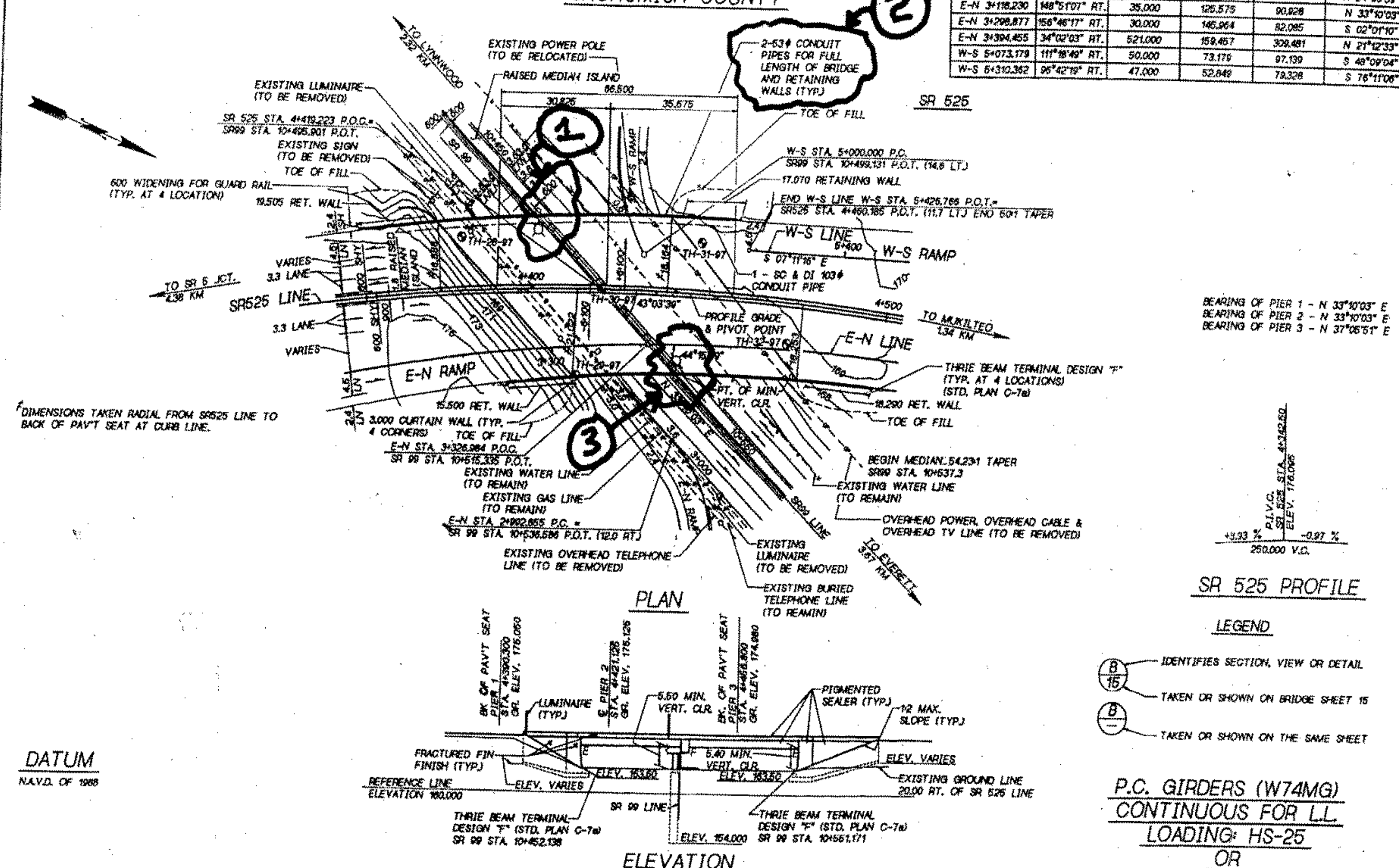


Install conduits as shown on the bridge plans and include expansion / deflection fittings for galvanized rigid steel conduits with inner ducts per conduit manufacturer.

Install luminaire/ITS base

SEC. 34, T. 28, N., R. 4E., W.M.
SNOHOMISH COUNTY

CURVE DATA					
P.I. STATION	DELTA	RADIUS	TANGENT	LENGTH	BK. TANGENT BRG.
SR525 4+471.005	36°53'41" RT.	594.000	198.143	382.497	N 24°00'39" W
E-N 3+118.230	148°51'07" RT.	35.000	125.575	90.928	N 33°10'03" E
E-N 3+298.877	156°46'17" RT.	30.000	145.964	82.085	S 02°01'10" W
E-N 3+394.455	34°02'03" RT.	521.000	159.457	309.481	N 21°12'33" W
W-S 5+073.179	111°18'49" RT.	50.000	73.179	97.139	S 48°09'04" W
W-S 5+310.362	96°42'19" RT.	47.000	52.849	79.328	S 76°11'06" E



*DIMENSIONS TAKEN RADIAL FROM SR525 LINE TO BACK OF PAV'T SEAT AT CURB LINE.

GRADE ELEVATION SHOWN ARE FINISH GRADES AT TOP OF ROADWAY SLAB ON SR 525 LINE AND ARE EQUAL TO PROFILE GRADE. SEE STD. PLAN H-9 FOR EMBANKMENT DETAILS AT RETAINING WALL ENDS.

DATUM
N.A.V.D. OF 1988

LEGEND
- B/15 IDENTIFIES SECTION, VIEW OR DETAIL — TAKEN OR SHOWN ON BRIDGE SHEET 15
- B/— TAKEN OR SHOWN ON THE SAME SHEET

P.C. GIRDERS (W74MG)
CONTINUOUS FOR L.L.
LOADING: HS-25
OR
TWO 107 KN AXLES @ 1.220 C'TRS.

C.S. 3127 - PROJ. NO. OL2300 - NORTHWEST REGION - JCT. SR 99 INTERCHANGE - SR 525 - JCT. SR 99 O'XING

Bridge Design Engr. G.G. RUTH
Supervisor J. A. VAN LUND
Designed By
Checked By N.E. BROWN
Detailed By J. PLESHA
Bridge Projects Engr. R.T. SHAEFER

10 WASH.

BRIDGE AND STRUCTURES OFFICE

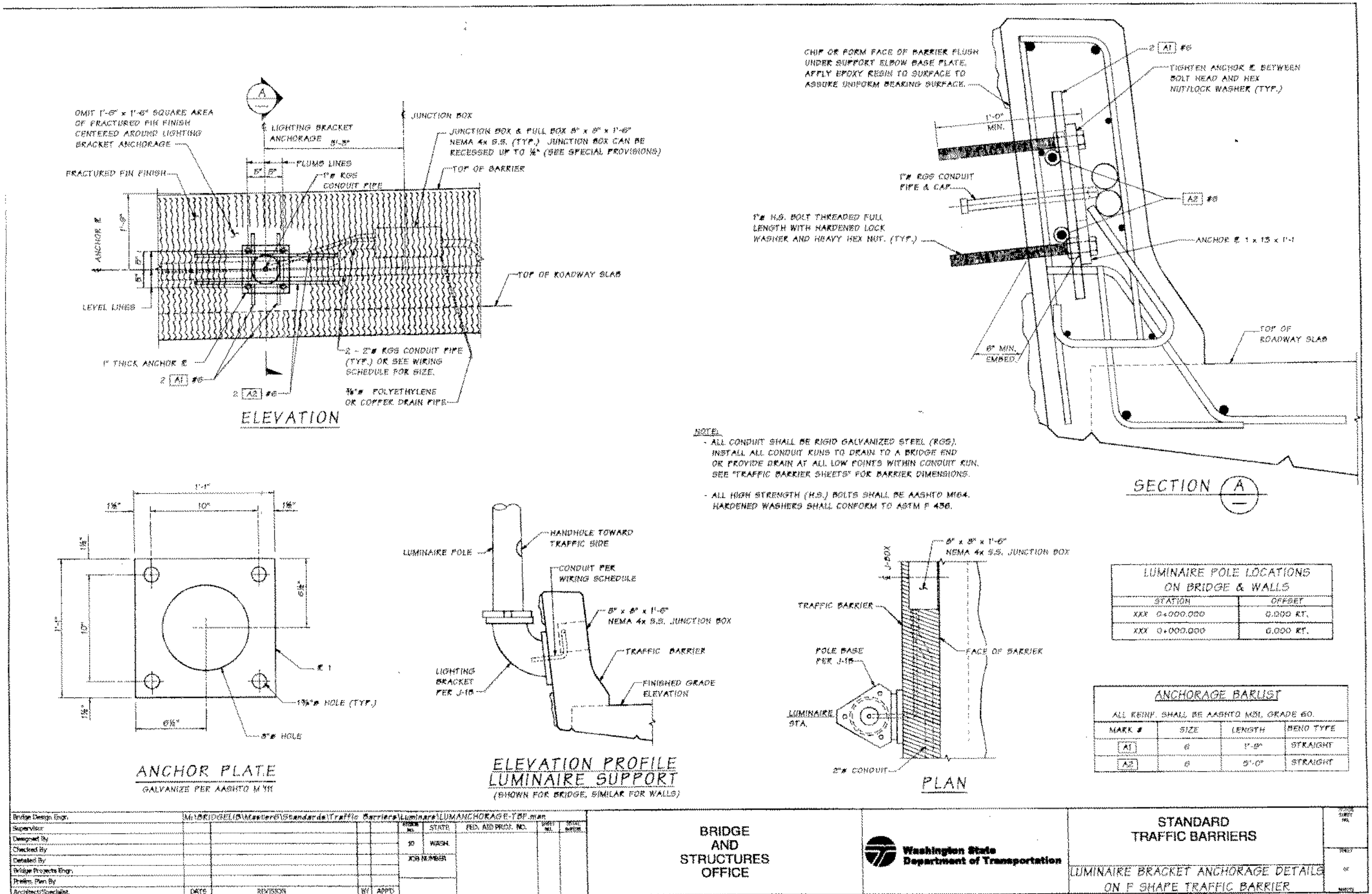
Washington State Department of Transportation

LUMINBASE1

LAYOUT

1
465
558

Install luminaire / ITS camera pole

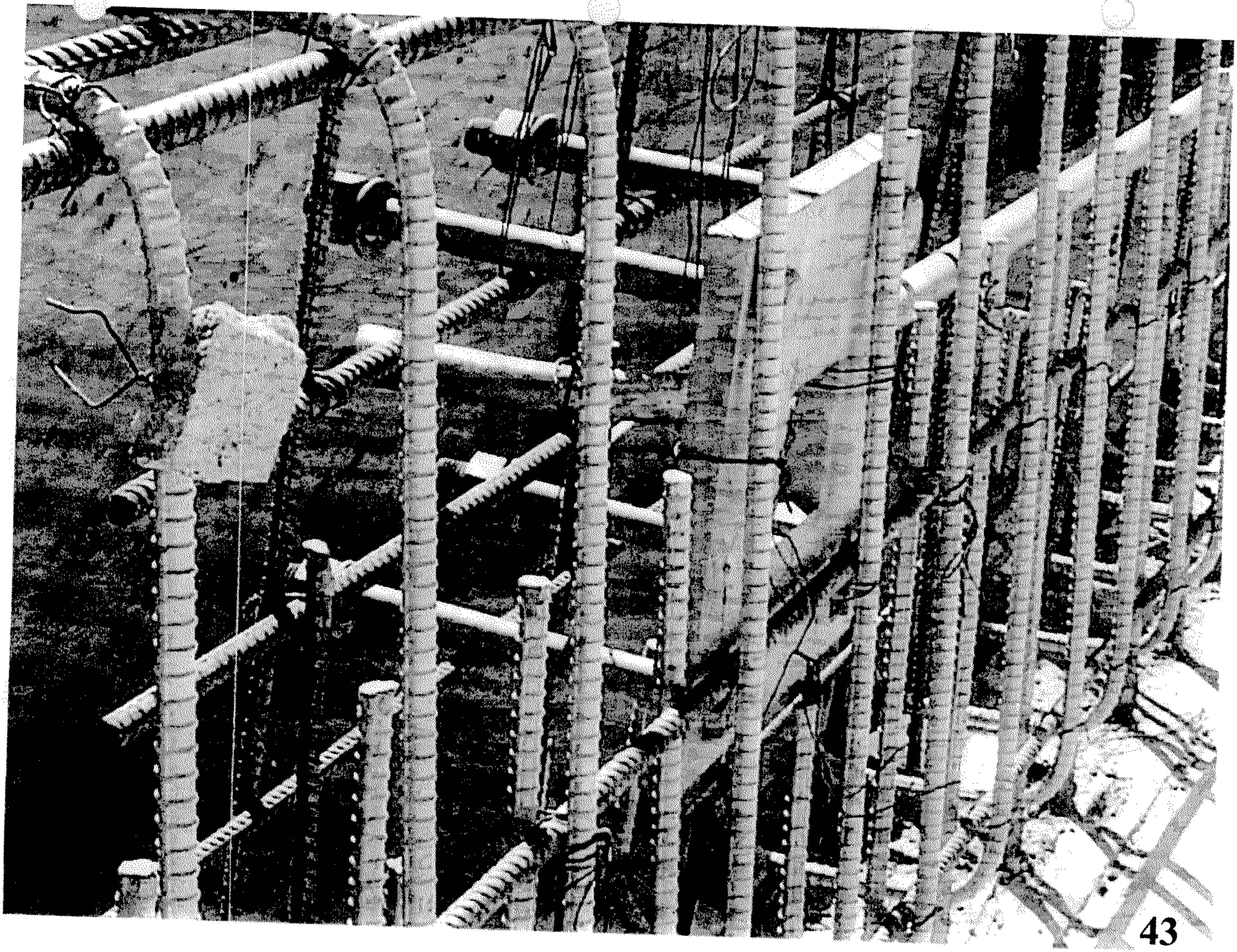


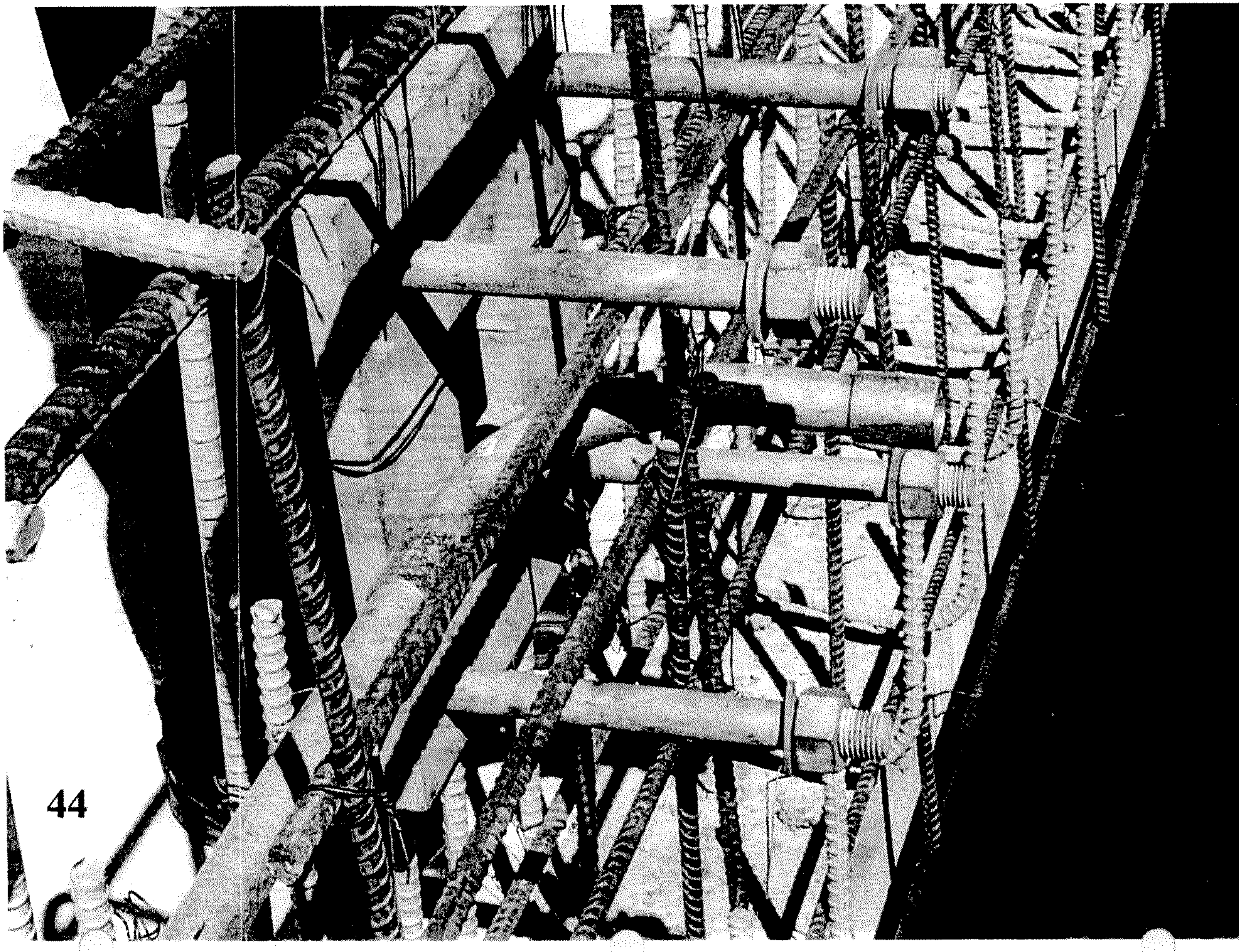
LUMINAIRE POLE LOCATIONS ON BRIDGE & WALLS	
STATION	OFFSET
XXX 0+000.000	0.000 RT.
XXX 0+000.000	0.000 RT.

ANCHORAGE BARLIST

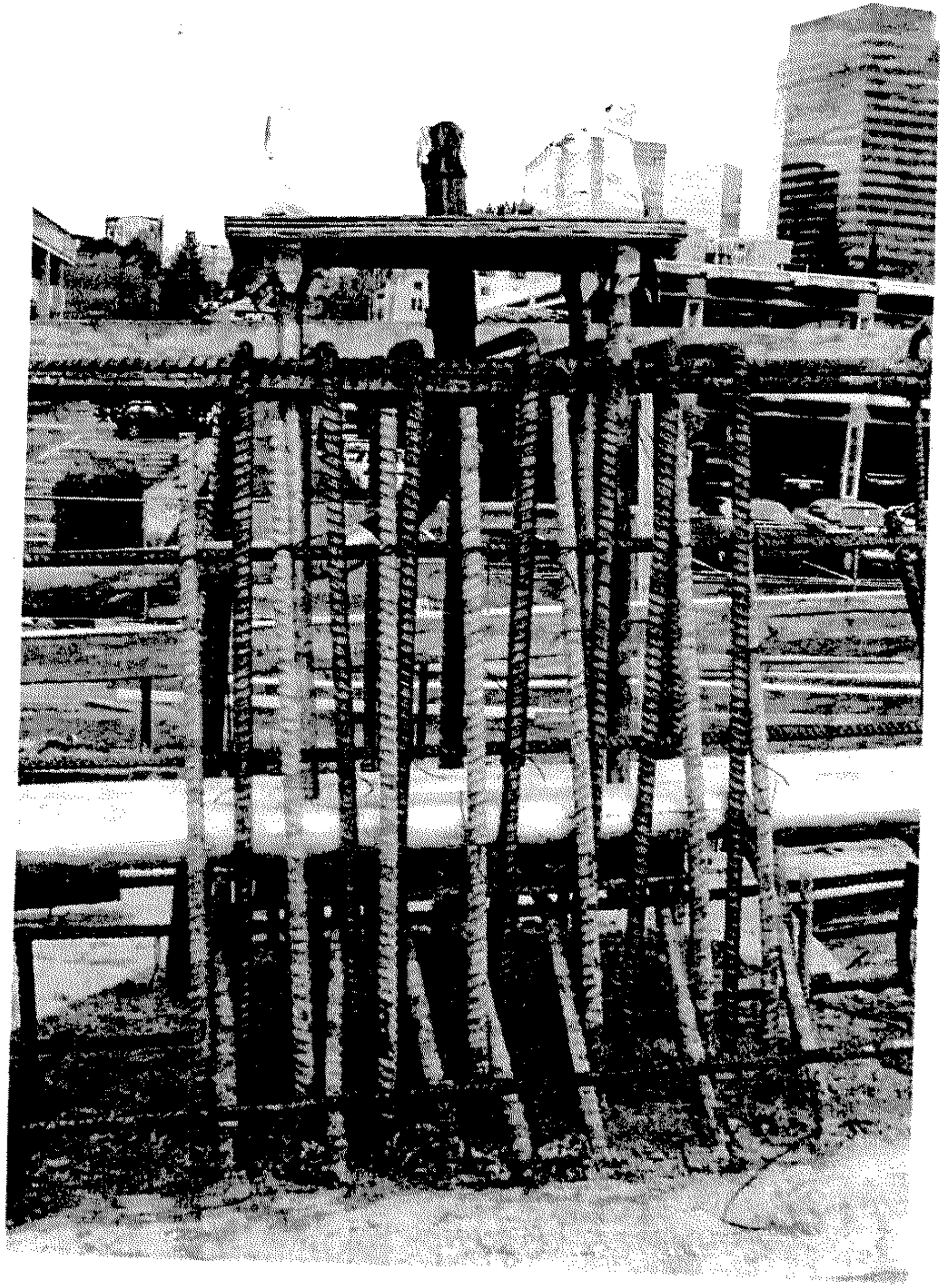
ALL REINF. SHALL BE AASHTO M31, GRADE 60.

MARK #	SIZE	LENGTH	BEND TYPE
A1	6	1'-9"	STRAIGHT
A2	6	5'-0"	STRAIGHT



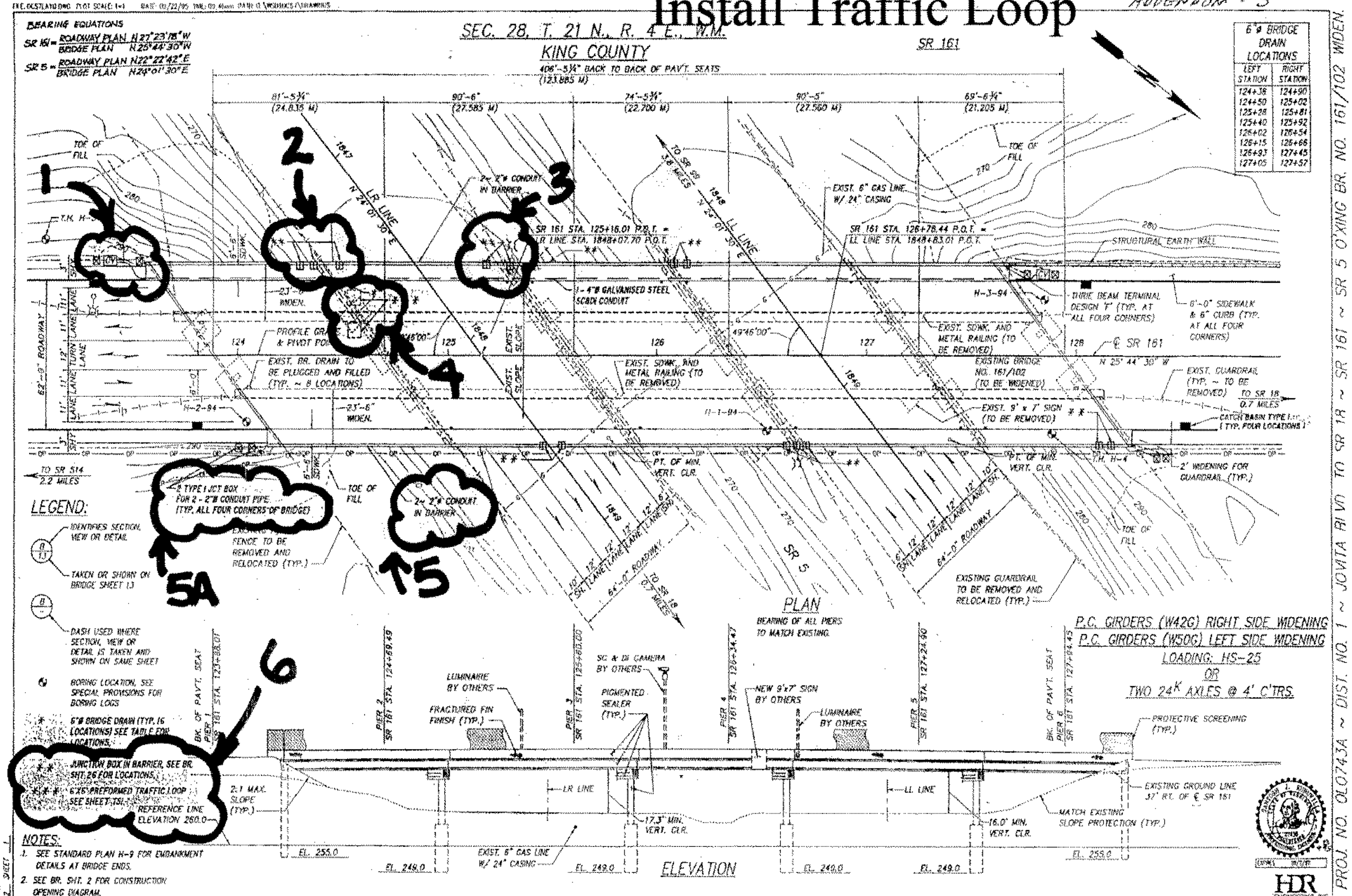


44



Install Traffic Loop

ADDENDUM #3



Bridge Design Engr.: M.H. LWIF	4/9..	
Supervisor:		
Designed By: D. HEINZ	9/95	
Checked By: R. D. BRAXMEYER	5/9..	
Detailed By:		
Bridge Plan Engr.: KARL KIRKER	5/9..	
Prelim. Plan By: C. E. C. MINNS		
Architect / Specialist: R. HAYS	5/9..	

STATE: WASH. JOB NUMBER: 95W045

TRAFFIC LOOPS

Washington State Department of Transportation

46

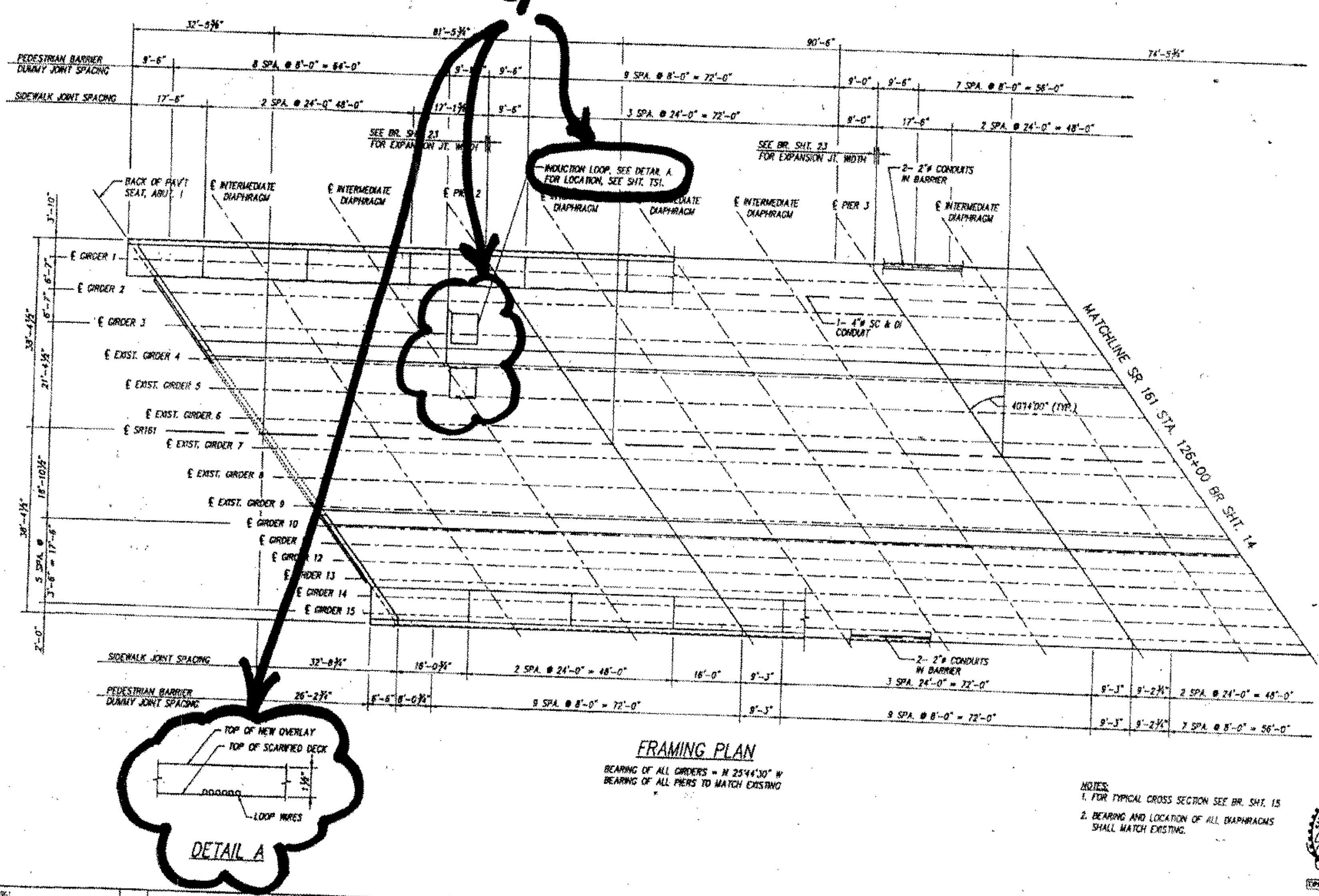
SR 161 JOVITA BLVD. TO SR 18 WIDEN - STAGE 1

LAYOUT

1

C.S. 1731 ~ PROJ. NO. OL0743A ~ DIST. NO. 1 ~ JOVITA BLVD. TO SR 18 ~ SR 161 ~ SR 5 O'XING BR. NO. 161/102 WIDEN.

Install Traffic Loop - Continued



Designed By	D. HEINZ	9/95	
Checked By	O. PARENT	9/95	
Detailed By	R. JACKSON	9/95	

JOB NUMBER 95W045

Washington State Department of Transportation

TRAFFICLOOP2.

47

SR 161 JOVITA BLVD. TO SR 18 WIDEN - STAGE 1

FRAMING PLAN I

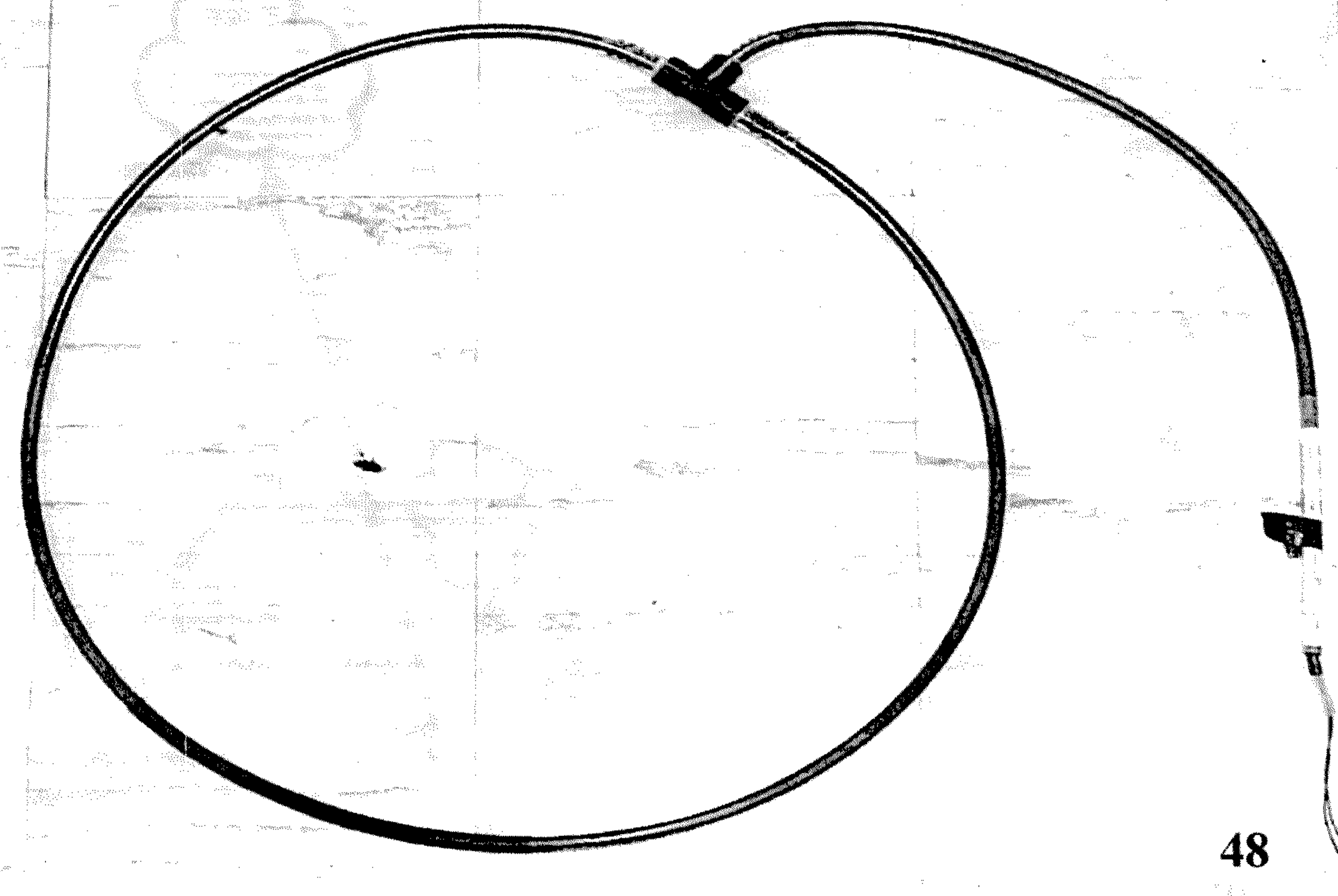
HDR ENGINEERING, INC.

3

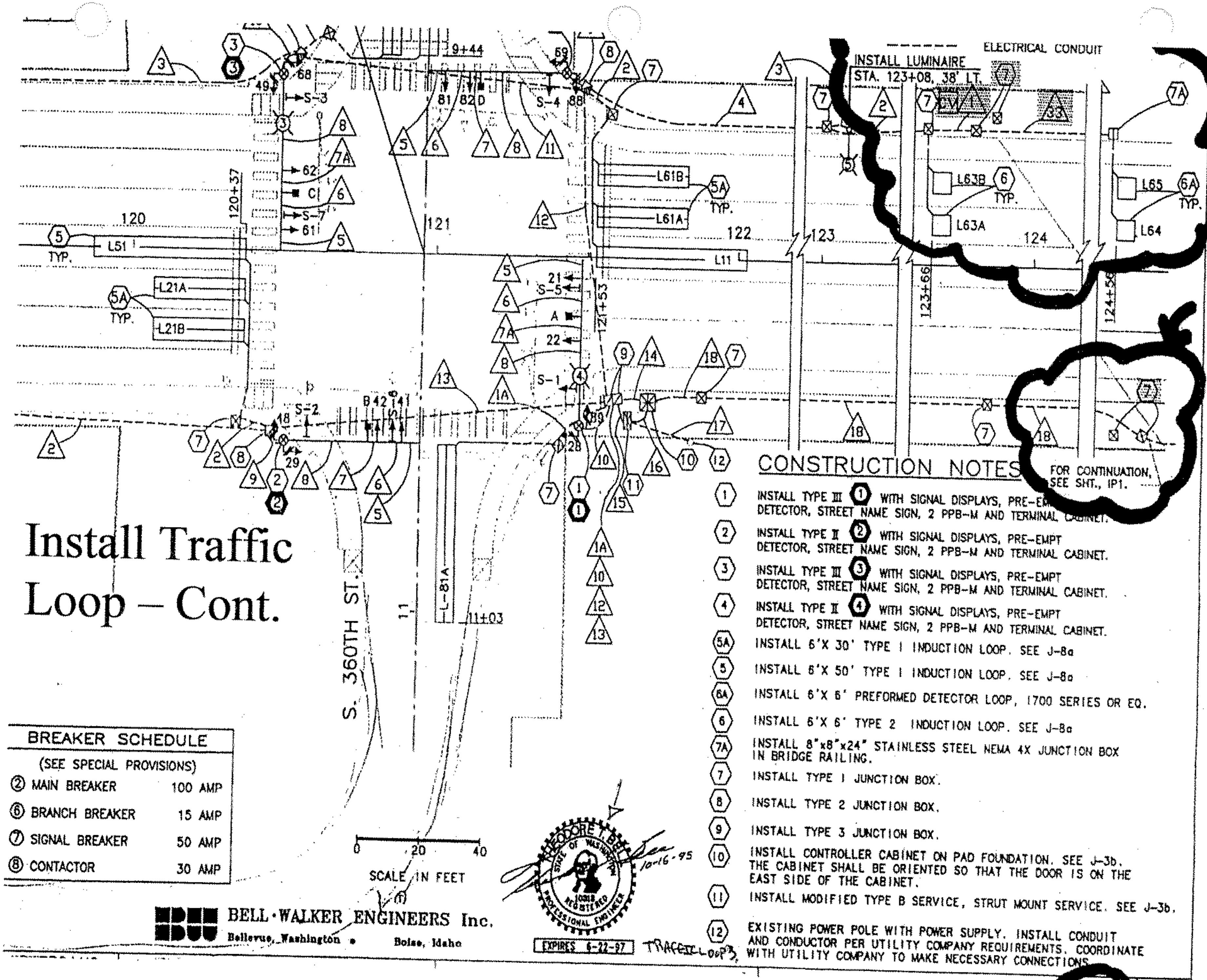
13

124 of 140

Preformed traffic loop



Install Traffic Loop – Cont.



BREAKER SCHEDULE

(SEE SPECIAL PROVISIONS)

②	MAIN BREAKER	100 AMP
⑥	BRANCH BREAKER	15 AMP
⑦	SIGNAL BREAKER	50 AMP
⑧	CONTACTOR	30 AMP

CONSTRUCTION NOTES

1. INSTALL TYPE III ① WITH SIGNAL DISPLAYS, PRE-EMPT DETECTOR, STREET NAME SIGN, 2 PPB-M AND TERMINAL CABINET.
2. INSTALL TYPE II ② WITH SIGNAL DISPLAYS, PRE-EMPT DETECTOR, STREET NAME SIGN, 2 PPB-M AND TERMINAL CABINET.
3. INSTALL TYPE III ③ WITH SIGNAL DISPLAYS, PRE-EMPT DETECTOR, STREET NAME SIGN, 2 PPB-M AND TERMINAL CABINET.
4. INSTALL TYPE II ④ WITH SIGNAL DISPLAYS, PRE-EMPT DETECTOR, STREET NAME SIGN, 2 PPB-M AND TERMINAL CABINET.

5A. INSTALL 6'X 30' TYPE I INDUCTION LOOP. SEE J-8a

5. INSTALL 6'X 50' TYPE I INDUCTION LOOP. SEE J-8a

6A. INSTALL 6'X 6' PREFORMED DETECTOR LOOP, 1700 SERIES OR EQ.

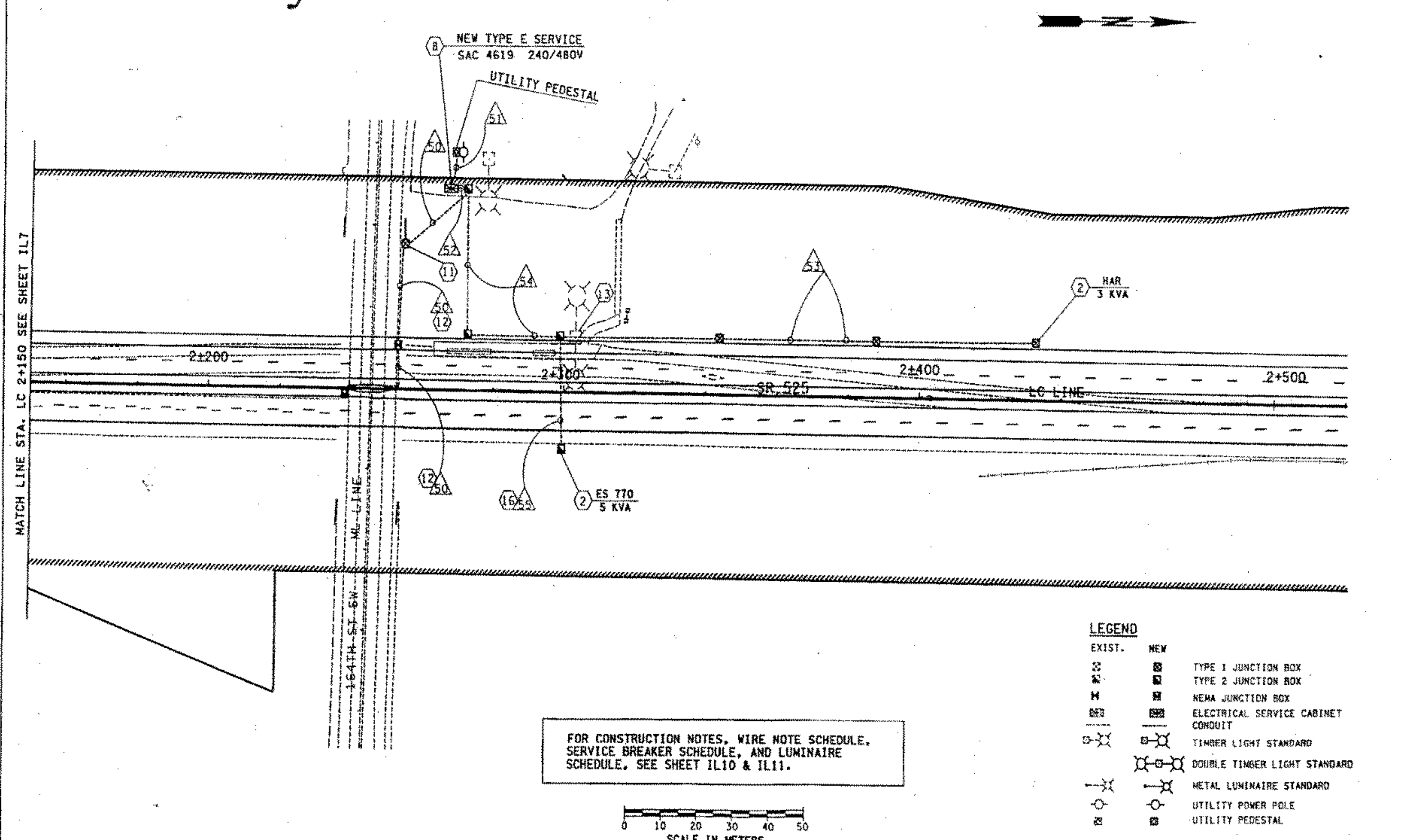
6. INSTALL 6'X 6' TYPE 2 INDUCTION LOOP. SEE J-8a

7A. INSTALL 8"x8"x24" STAINLESS STEEL NEMA 4X JUNCTION BOX IN BRIDGE RAILING.

7. INSTALL TYPE I JUNCTION BOX.
8. INSTALL TYPE 2 JUNCTION BOX.
9. INSTALL TYPE 3 JUNCTION BOX.
10. INSTALL CONTROLLER CABINET ON PAD FOUNDATION. SEE J-3b. THE CABINET SHALL BE ORIENTED SO THAT THE DOOR IS ON THE EAST SIDE OF THE CABINET.
11. INSTALL MODIFIED TYPE B SERVICE, STRUT MOUNT SERVICE. SEE J-3b.
12. EXISTING POWER POLE WITH POWER SUPPLY. INSTALL CONDUIT AND CONDUCTOR PER UTILITY COMPANY REQUIREMENTS. COORDINATE WITH UTILITY COMPANY TO MAKE NECESSARY CONNECTIONS.

Externally Mounted Conduit

T.27N. R.3E. W.M.



PLOT9 09 MAR 1999 c:\seth\joe\sr525\sr525ele.dgn KoyS

DESIGNED BY	J. PRZYCHODZEN			
ENTERED BY	T. VANASSCHE			
CHECKED BY	D. DO			
PROJ. ENGR.	M. COTTEN			
REGIONAL ADM.	J. OKAMOTO			
		DATE	DATE	REVISION

REGION NO. 10 | STATE WASH | FED.AID PROJ.NO.

JOB NUMBER L1610

CONTRACT NO.

ENVIRONMENTAL AND ENGINEERING SERVICE CENTER

Washington State Department of Transportation

EXTCOND1.

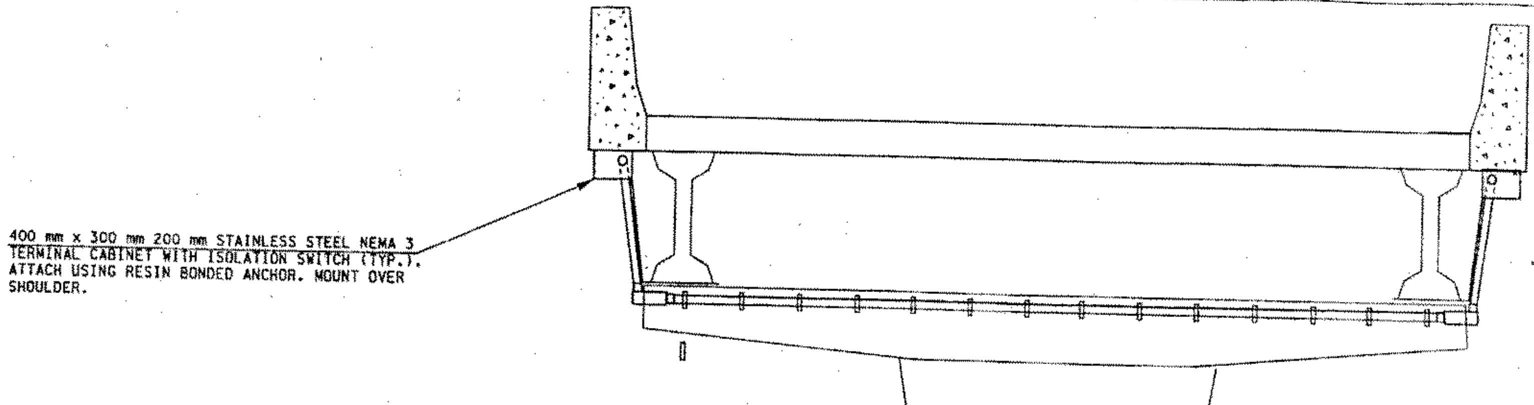
50 SR 525 I-5 TO SR 99

ILLUMINATION PLAN

IL8

SHEET 272 OF 412 SHEETS

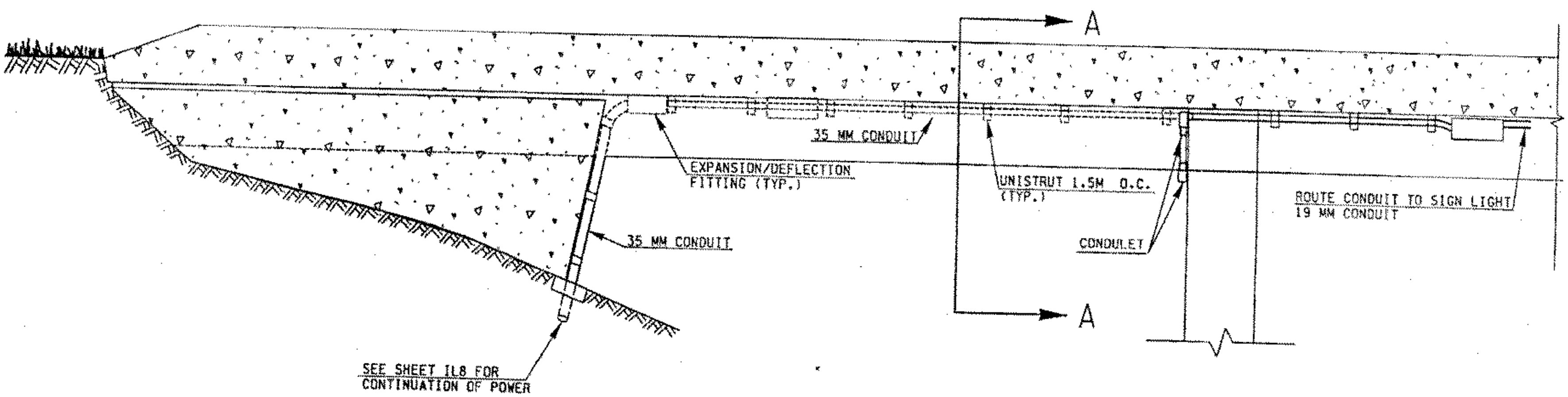
PLOT14 09 MAR 1999 g:\soth\joe\sr525\sr525ele.dgn KovS



Externally Mounted Conduit

VIEW A - A

profile view of structure with conduit, DX fitting, condulets, isolation switch enclosure, surface mounted junction box, etc.



CONDUIT ROUTING DETAIL

DESIGNED BY J. PRZYCHODZEN					
ENTERED BY T. VANASSCHE					
CHECKED BY D. DO					
PROJ. ENGR. M. COTTEN					
REGIONAL ADM. J. OKAMOTO					
	DATE	DATE	REVISION	BY	

REGION NO. 10 | STATE WASH | FED. AID PROJ. NO.

JOB NUMBER L1610

CONTRACT NO.

ENVIRONMENTAL AND ENGINEERING SERVICE CENTER

Washington State Department of Transportation

EXTCOND2.

SR 525
I-5 TO SR 99

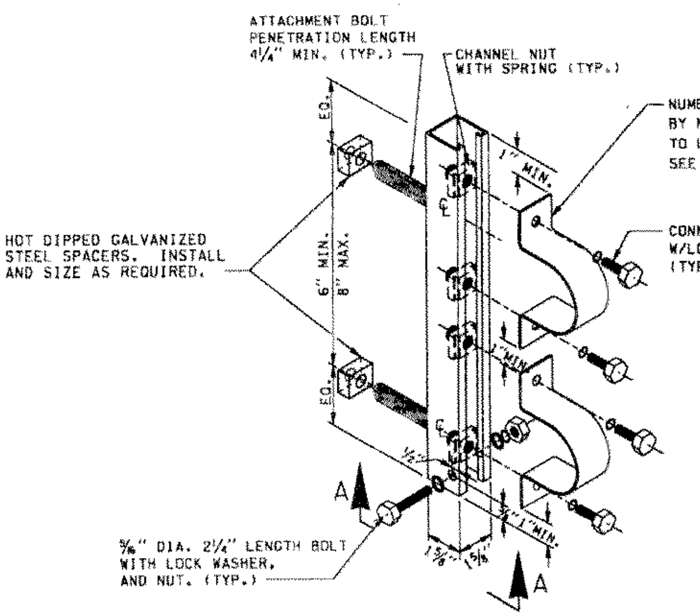
51

ED1

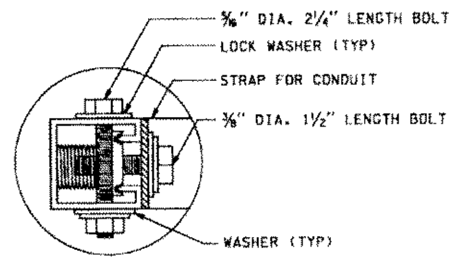
ELECTRICAL DETAILS

SHEET 276 OF 412 SHEETS

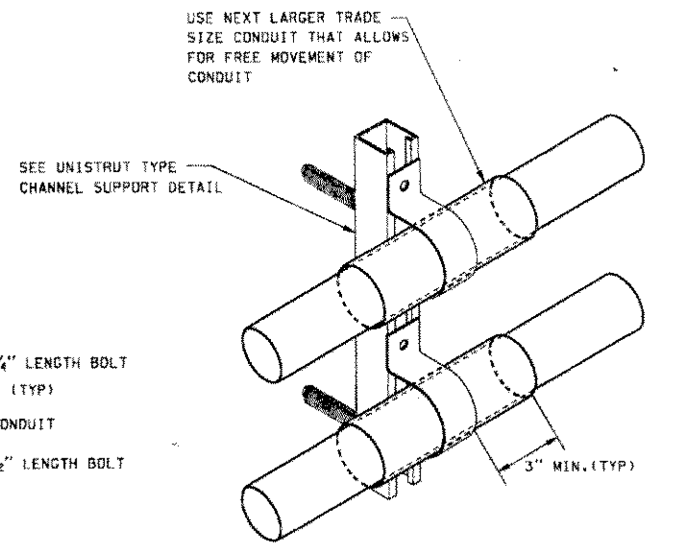
Externally Mounted Conduit – attachment detail



UNISTRUT TYPE CHANNEL SUPPORT DETAIL



DETAIL A



PVC CONDUIT SUPPORT DETAIL

(FOR UTILITY COMPANY USE - ONLY ALLOWED IN RARE INSTANCES)

NOTES

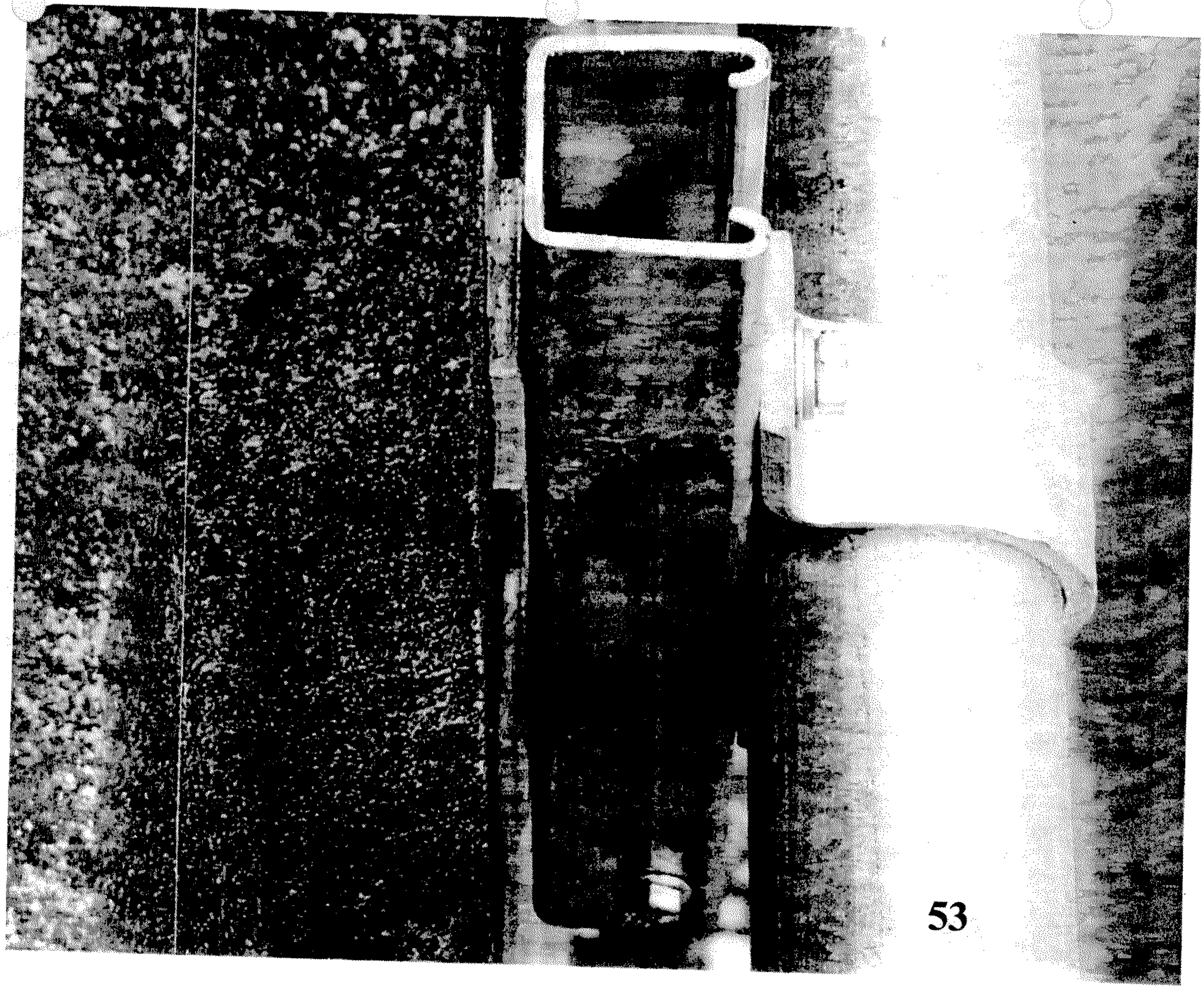
MOUNTING HARDWARE DETAILS ARE PROVIDED FOR ILLUSTRATIVE PURPOSES ONLY. THE CONTRACTOR MAY PROPOSE GEOMETRIC ATTACHMENT MODIFICATIONS, SUBJECT TO APPROVAL BY THE ENGINEER.

DRILLING THROUGH REINFORCING STEEL IS NOT ALLOWED. IF STEEL IS HIT WHILE DRILLING, THE LOCATION SHALL BE MOVED AND THE ABANDONED HOLE FILLED WITH GROUT CONFORMING TO SECTION 6-02.3(20). THERE SHALL BE A MINIMUM 3" EDGE DISTANCE TO THE CENTERLINE OF ANCHOR HOLES IN CONCRETE. MOUNT THE UNISTRUT TYPE SUPPORT USING AN APPROVED RESIN BONDED ANCHOR SYSTEM, INSTALLED PER MANUFACTURERS RECOMMENDATION IN DRY CONDITIONS. RESIN BONDED ANCHORS SHALL BE STAINLESS STEEL AND SHALL BE A MINIMUM OF ⅜" DIA. UNLESS THE PLANS REQUIRE LARGER ANCHORS. (EXPANSION ANCHORS ARE NOT ALLOWED.)

RIGID GALVANIZED STEEL CONDUIT		
NOMINAL TRADE SIZE IN.	CONDUIT STRAP DIAMETER OUTSIDE	INSIDE
½	0.840	0.632
¾	1.050	0.836
1	1.315	1.063
1¼	1.660	1.394
1½	1.900	1.624
2	2.375	2.083
2½	2.875	2.489
3	3.500	3.090
3½	4.000	3.570
4	4.500	4.050
5	5.563	5.073
6	6.625	6.093

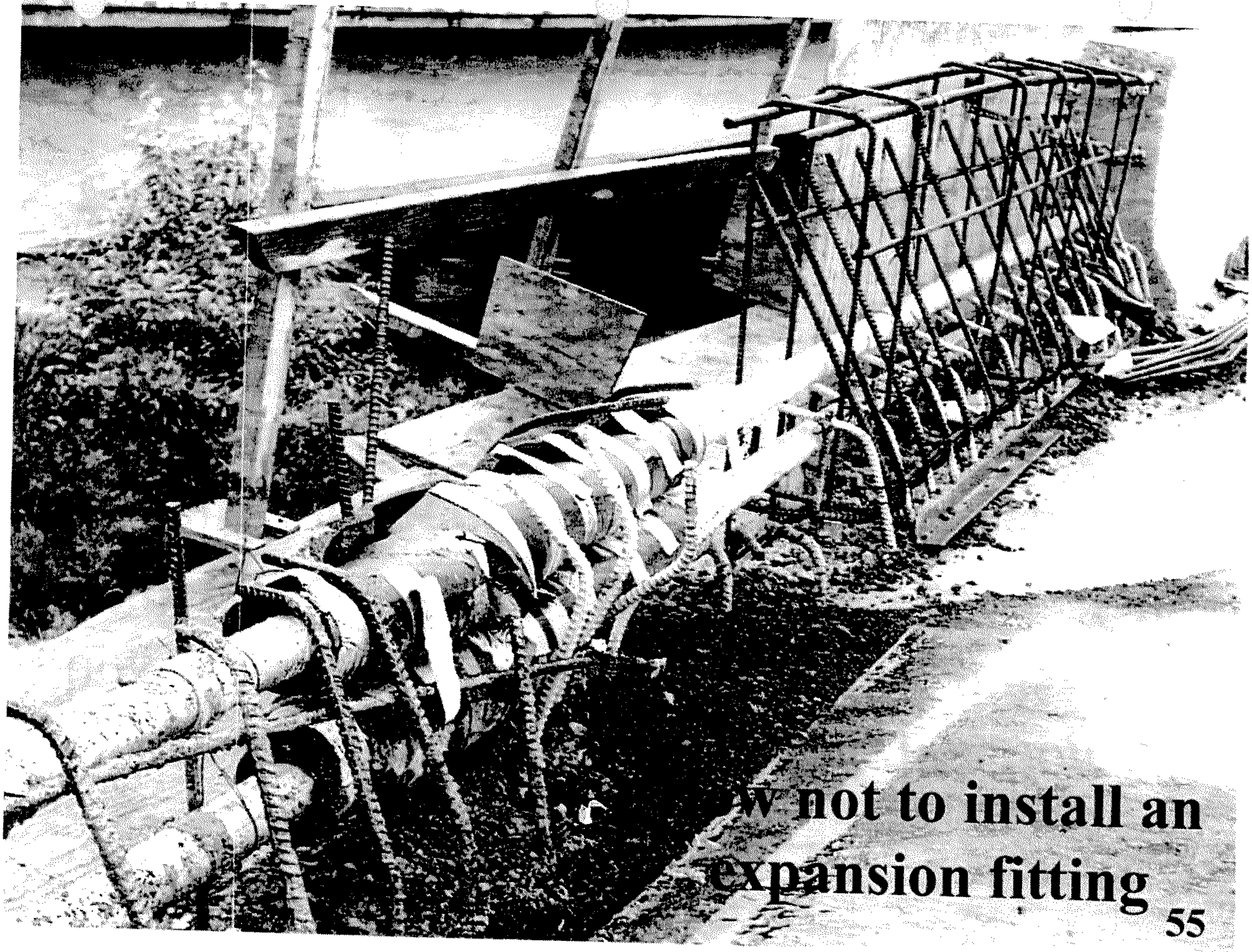
SCHEDULE 40 PVC		
NOMINAL TRADE SIZE IN.	CONDUIT STRAP DIAMETER OUTSIDE	INSIDE
½	0.840	0.622
¾	1.050	0.824
1	1.315	1.049
1¼	1.660	1.380
1½	1.900	1.610
2	2.375	2.067
2½	2.875	2.469
3	3.500	3.068
3½	4.000	3.548
4	4.500	4.026
5	5.563	5.047
6	6.625	6.065

SCHEDULE 80 PVC		
NOMINAL TRADE SIZE IN.	CONDUIT STRAP DIAMETER OUTSIDE	INSIDE
½	0.840	0.546
¾	1.050	0.742
1	1.315	0.957
1¼	1.660	1.278
1½	1.900	1.500
2	2.375	1.939
2½	2.875	2.323
3	3.500	2.900
4	4.500	3.826
5	5.563	4.813



53


How not to install conduits & junction boxes


w not to install an
expansion fitting

Summary

- Discussed installation of conduit, junction boxes, standard bases, loops & stub outs.
- With this class & the handouts we can install conduit, junction boxes, ITS(SC&DI) camera pole or luminaire bases, traffic loops or other electrical system components into a bridge or structure.
- We can make comments on designs by others.

Where to get more information

- Contact Mike Bauer- Special Provisions & Cost Estimating Engineer @ 360-705-7190
- Contact Tony Messmer- Bridge Designer (Bridge Rail Specialist) @ 360-705-7216
- Contact Terry Thayer - HQ Traffic Office @ 360-705-7290

Are there any questions?

Electrical Services

Presented by: Terry Thayer

HQ Traffic Office

RCW = Revised Code of Washington
These are laws written by the state legislature.
The constitution of the State is contained within the first portion of the RCW's.

WAC = Washington Administrative Code
The legislature creates job performance expectations or job duties (RCW's). The state agencies then further define and bring to life these performance expectations through writing these administrative rules.

EUSERC Specifications

WAC 296-46B-230 Wiring and protection -- Services.

001 General service requirements.

(1) The owner, the owner's agent, or the electrical contractor making the installation $\boxed{\text{must}}$ consult the serving utility regarding the utility's service entrance requirements for equipment location and meter equipment requirements before installing the service and equipment. Provisions for a meter and related equipment, an attachment of a service drop, or an underground service lateral must be made at a location acceptable to the serving utility. The point of contact for a service drop must permit the clearances required by the NEC.

(3) The height of the center of the service meter must be as required by the serving utility. Secondary instrument transformer metering conductor(s) are not permitted in the service raceway.

042 Service conductor - size and rating.

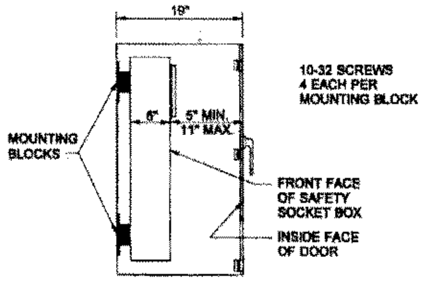
(7) If the service conductors have a lesser ampacity than the overcurrent protection or the equipment rating that they terminate in or on, an identification plate showing the ampacity of the conductors $\boxed{\text{must}}$ be installed on the service equipment.

[Statutory Authority: RCW 19.28.006, 19.28.010, 19.28.031, 19.28.041, 19.28.061, 19.28.101, 19.28.131, 19.28.161, 19.28.171, 19.28.191, 19.28.201, 19.28.211, 19.28.241, 19.28.251, 19.28.271, 19.28.311, 19.28.321, 19.28.400, 19.28.420, 19.28.490, 19.28.551, 2002 c 249, chapters 34.05 and 19.28 RCW. 03-09-111, § 296-46B-230, filed 4/22/03, effective 5/23/03.]

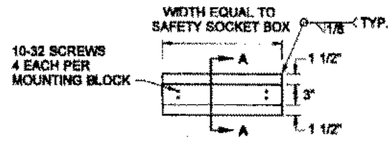
GENERAL NOTES

200 AMP TYPE 120/240 1ø SERVICE CABINET

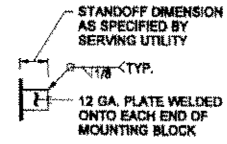
1. SEE STANDARD SPECIFICATION 9-29.24, SERVICE CABINETS.
2. HINGES SHALL HAVE STAINLESS STEEL OR BRASS PINS.
3. CABINETS SHALL BE RATED NEMA 3R AND SHALL INCLUDE TWO RAIN TIGHT VENTS.
4. METERING EQUIPMENT DOOR SHALL BE PAD LOCKABLE. EACH DOOR SHALL BE GASKETED. INSTALL BEST CX CONSTRUCTION CORE ON RIGHT DOOR. SEE DOOR HINGE DETAIL, SHEET 1 OF 2.
5. THE FOLLOWING EQUIPMENT WITHIN THE SERVICE ENCLOSURE SHALL HAVE AN APPROPRIATELY ENGRAVED PHENOLIC NAME PLATE ATTACHED WITH SCREWS OR RIVETS: KEY NUMBERS 2, 3, 4, 6, 7, 8, 9 AND 16. KEY NUMBER 4 NAME PLATE SHALL READ: "PHOTOCELL BYPASS TEST ON" AND "PHOTOCELL TEST OFF- AUTOMATIC". SEE SERVICE CABINET DETAIL.
6. METERING ARRANGEMENTS VARY WITH DIFFERENT SERVING UTILITIES. THE UTILITY MAY REQUIRE METER BASE MOUNTING IN THE ENCLOSURE, ON THE SIDE OR ON THE BACK OF THE ENCLOSURE. THE UTILITY MAY REQUIRE THE DIMENSION BETWEEN THE DOOR AND THE FRONT OF THE SAFETY SOCKET BOX TO BE LESS THAN THE 11 INCHES SHOWN IN THE LEFT SIDE- SAFETY SOCKET BOX MOUNTING DETAIL. THE CONTRACTOR SHALL VERIFY THE SERVING UTILITY'S REQUIREMENTS PRIOR TO FABRICATION OF AND INSTALLING THE SERVICE EQUIPMENT.
7. DIMENSIONS SHOWN ARE MINIMUM AND SHALL BE ADJUSTED TO ACCOMMODATE THE VARIOUS SIZES OF EQUIPMENT INSTALLED.
8. ALL BUSSWORK SHALL BE HIGH GRADE COPPER AND SHALL EQUAL OR EXCEED THE MAIN BREAKER RATING. ALL BREAKERS SHALL BOLT ONTO THE BUSSWORK. JUMPERING OF BREAKERS SHALL NOT BE ALLOWED. BUSSWORK SHALL ACCOMMODATE ALL FUTURE EQUIPMENT AS SHOWN IN THE BREAKER SCHEDULE.
9. THE PHOTOCELL UNIT SHALL BE CENTERED IN THE PHOTOCELL ENCLOSURE TO PERMIT 360 DEGREE ROTATION OF THE PHOTOCELL WITHOUT REMOVAL OF THE PHOTOCELL UNIT OR THE PHOTOCELL ENCLOSURE.
10. ALL INTERNAL WIRE RUNS SHALL BE IDENTIFIED WITH "TO - FROM" CODED TAGS LABELED WITH THE CODE LETTERS AND/OR NUMBERS SHOWN ON THE SCHEDULES. APPROVED PVC OR POLYOLEFIN WIRE MARKING SLEEVES SHALL BE USED.
11. ALL NUTS, BOLTS AND WASHERS USED FOR MOUNTING THE PHOTOCELL ENCLOSURE SHALL BE STAINLESS STEEL.
12. A 1% TOLERANCE IS ALLOWED FOR ALL DIMENSIONS.
13. UNISTRUT TYPE CHANNEL AND MOUNTING HARDWARE COMPONENTS SHALL BE STAINLESS STEEL. CONDUIT CLAMPS SHALL BE HOT DIPPED, GALVANIZED STEEL OR STAINLESS STEEL.
14. INSTALL CONDUIT COUPLINGS ON ALL CONDUITS. PLACE COUPLINGS FLUSH WITH TOP OF CONCRETE FOUNDATION.
15. NOTE 15 HAS BEEN DELETED.
16. THE METER BASE PORTION OF THIS SERVICE WAS DESIGNED TO MEET METERING PORTION OF EUSERC DRAWING 300 REQUIREMENTS.
17. WHEN USING ALTERNATE DOOR HINGE: REMOVE HINGE PIN PRIOR TO WELDING HINGE TO CABINET AND PRIOR TO HOT DIP GALVANIZING CABINET. AFTER GALVANIZING, REPLACE PIN WITH BRASS PIN AND SOLDER IN PLACE.



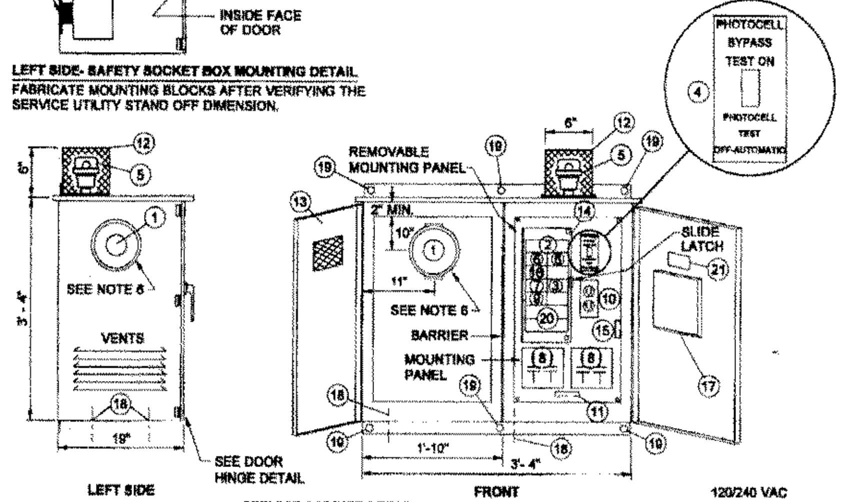
LEFT SIDE- SAFETY SOCKET BOX MOUNTING DETAIL
FABRICATE MOUNTING BLOCKS AFTER VERIFYING THE SERVICE UTILITY STAND OFF DIMENSION.



MOUNTING BLOCK DETAIL
12 GA. - MATERIAL TO BE SAME AS CABINET MATERIAL



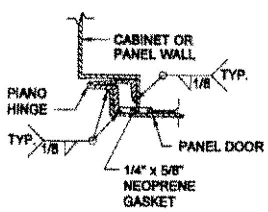
SECTION A-A



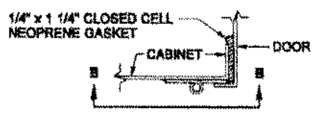
SERVICE CABINET DETAIL

KEY

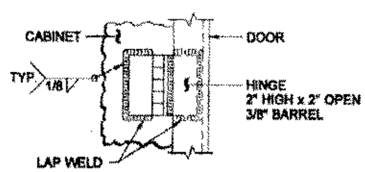
1. METER BASE PER SERVING UTILITY REQUIREMENTS. AS A MINIMUM, THE METER BASE SHALL BE SAFETY SOCKET BOX WITH FACTORY INSTALLED TEST BYPASS FACILITY THAT MEETS THE REQUIREMENTS OF EUSERC DRAWING 305.
2. MAIN BREAKER (SEE BREAKER SCHEDULE)
3. PHOTOCELL BREAKER (SPST 15 AMP - 120/240 VOLT)
4. TEST SWITCH (SPDT SNAP ACTION, POSITIVE CLOSE 15 AMP - 120/277 VOLT - "T" RATED)
5. PHOTOELECTRIC CONTROL, STD. SPEC. 9 - 29.11(2)
6. BRANCH BREAKER (SEE BREAKER SCHEDULE)
7. SIGNAL BREAKER (SEE BREAKER SCHEDULE)
8. CONTACTOR (SEE BREAKER SCHEDULE)
9. RECEPTACLE BREAKER (SPST 20 AMP - 120/240 VOLT)
10. RECEPTACLE, GROUNDED (GFCI 20 AMP - 125 VOLT)
11. NEUTRAL BUSS, 14 LUG COPPER
12. PHOTOCELL ENCLOSURE - ENCLOSURE TO BE FABRICATED FROM 5/8" EXPANDED STEEL MESH WITH WELDED SEAMS AND MOUNTING FLANGES. HOT DIP GALVANIZED AFTER FABRICATION. TYPE 5052 - H32 ALUMINUM WITH 5/8" x 5/8" OPENINGS EQUIVALENT TO 5/8" EXPANDED STEEL MESH MAY BE USED AS ALTERNATIVE MATERIAL. SEE PHOTOCELL ENCLOSURE MOUNTING DETAIL, SHEET 2 OF 2.
13. HINGED FRONT FACING DOOR WITH 4" x 4" MIN. POLISHED WIRE GLASS WINDOW.
14. HINGED DEAD FRONT WITH 1/4 TURN FASTENERS OR SLIDE LATCH.
15. CABINET MAIN BONDING JUMPER. BUSS SHALL BE 4 LUG TINNED COPPER. SEE CABINET MAIN BONDING JUMPER DETAIL ON SHEET 2 OF 2.
16. SPARE BRANCH BREAKER (DPST 20AMP- 120/240 VOLT)
17. METAL WIRING DIAGRAM HOLDER
18. 1/4" DIAMETER DRAIN HOLE. DRILL BEFORE GALVANIZING.
19. MOUNTING HOLE. SEE SERVICE CABINET MOUNTING DETAILS.
20. 18 CIRCUIT PANEL BOARD - MINIMUM SIZE WITH SEPARATE MAIN BREAKER.
21. LABEL CABINET WITH BUSSWORK RATING.



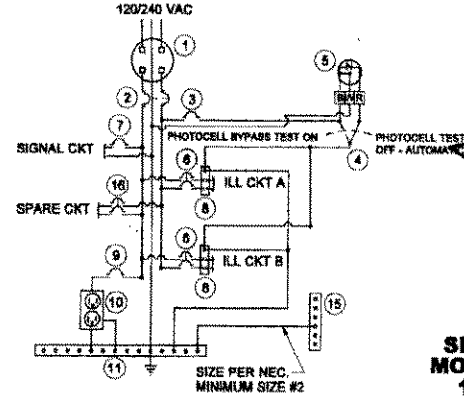
DOOR HINGE DETAIL



DOOR HINGE DETAIL
ALTERNATE FOR TYPE B MODIFIED CABINET
SEE NOTE 17



VIEW B-B



WIRING SCHEMATIC

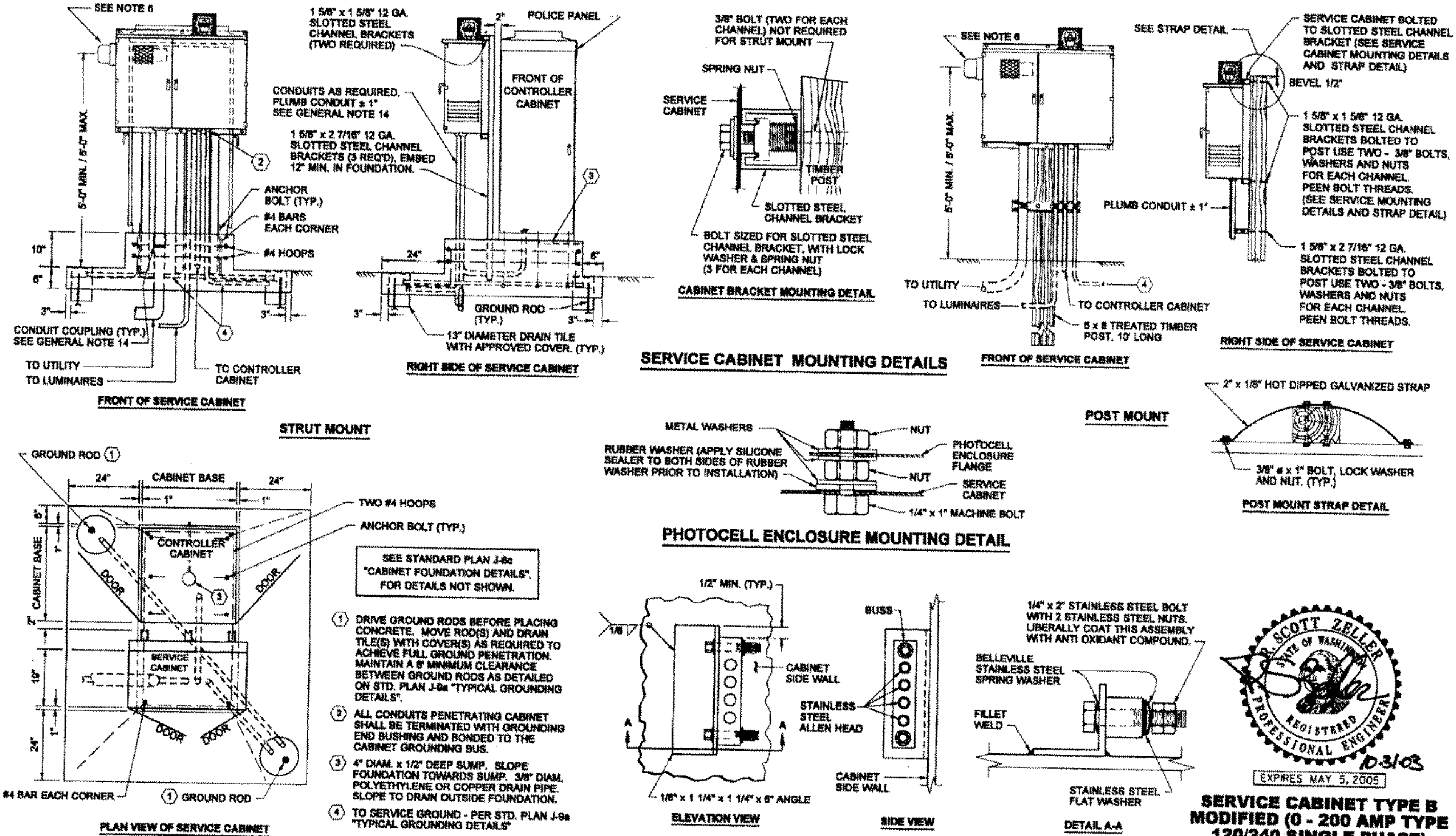
R. SCOTT ZELLER
STATE OF WASHINGTON
REGISTERED PROFESSIONAL ENGINEER
10-31-03
EXPIRES MAY 5, 2005

SERVICE CABINET TYPE B MODIFIED (0 - 200 AMP TYPE 120/240 SINGLE PHASE) STANDARD PLAN J-3b

SHEET 1 OF 2 SHEETS

APPROVED FOR PUBLICATION
Harold Peterfeso 11-5-03
STATE DESIGN ENGINEER   DATE
Washington State Department of Transportation

DATE	REVISION	BY
09/2003	REVISED NOTE 13	HHG



(1) DRIVE GROUND RODS BEFORE PLACING CONCRETE. MOVE ROD(S) AND DRAIN TILE(S) WITH COVER(S) AS REQUIRED TO ACHIEVE FULL GROUND PENETRATION. MAINTAIN A 6' MINIMUM CLEARANCE BETWEEN GROUND RODS AS DETAILED ON STD. PLAN J-9a "TYPICAL GROUNDING DETAILS".

(2) ALL CONDUITS PENETRATING CABINET SHALL BE TERMINATED WITH GROUNDING END BUSHING AND BONDED TO THE CABINET GROUNDING BUS.

(3) 4" DIAM. x 1/2" DEEP SUMP. SLOPE FOUNDATION TOWARDS SUMP. 3/8" DIAM. POLYETHYLENE OR COPPER DRAIN PIPE. SLOPE TO DRAIN OUTSIDE FOUNDATION.

(4) TO SERVICE GROUND - PER STD. PLAN J-9a "TYPICAL GROUNDING DETAILS"

SERVICE CABINET TYPE B MODIFIED (0 - 200 AMP TYPE 120/240 SINGLE PHASE) STANDARD PLAN J-3b

SHEET 2 OF 2 SHEETS

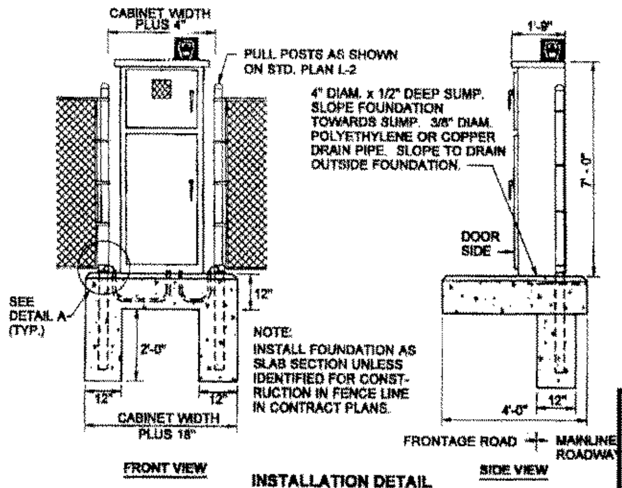
APPROVED FOR PUBLICATION

Harold Peterfeso 11-5-03

STATE DESIGN ENGINEER DATE

Washington State Department of Transportation

09/2003	REVISED SERVICE CABINET MOUNTING DETAIL	HHS
DATE	REVISION	BY



INSTALLATION DETAIL

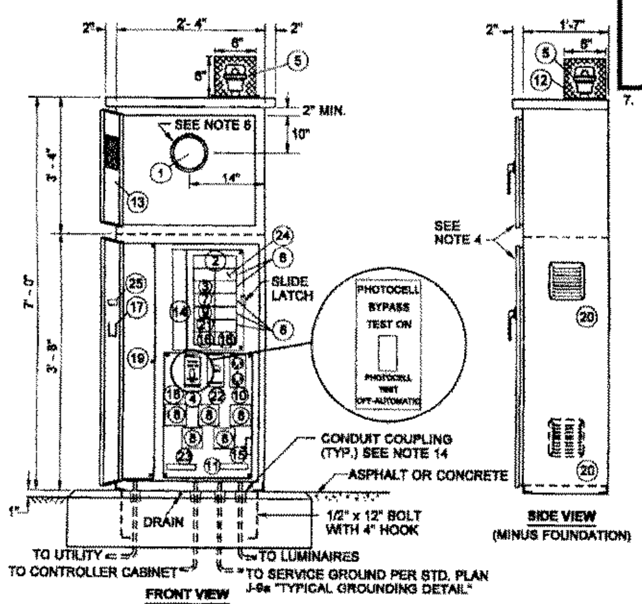
GENERAL NOTES

200 AMP TYPE 120/240 1ø SERVICE CABINET

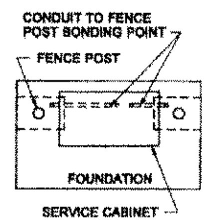
1. SEE STD. SPECIFICATION 9-29.24, SERVICE CABINETS.
2. HINGES SHALL HAVE STAINLESS STEEL OR BRASS PINS.
3. CABINETS SHALL BE RATED NEMA 3R AND SHALL INCLUDE TWO RAIN TIGHT VENTS.
4. METERING EQUIPMENT DOOR SHALL BE PAD LOCKABLE. EACH DOOR SHALL BE GASKETED. INSTALL BEST CX CONSTRUCTION CORE ON BOTTOM DOOR. SEE DOOR HINGE DETAIL, STANDARD PLAN J-3b. CONCEALED HEAVY DUTY STAINLESS STEEL LIFT OFF HINGES ARE ALLOWED AS AN ALTERNATIVE TO DOOR HINGE DETAIL SHOWN ON STANDARD PLAN J-3b. UPPER DOOR SHALL HAVE 2 HINGES AND LOWER DOOR SHALL HAVE 3 HINGES. THE LOWER DOOR SHALL HAVE A TWO POSITION DOOR STOP ASSEMBLY.
5. THE FOLLOWING EQUIPMENT WITHIN THE SERVICE ENCLOSURE SHALL HAVE AN APPROPRIATELY ENGRAVED PHENOLIC NAME PLATE ATTACHED WITH SCREWS OR RIVETS:
   KEY NUMBERS 2, 3, 4, 6, 7, 8, 9, 16 AND 21.
   KEY NUMBER 4 NAME PLATE SHALL READ: "PHOTOCELL BYPASS TEST ON" AND "PHOTOCELL TEST OFF- AUTOMATIC". SEE SERVICE CABINET DETAIL.
6. METERING ARRANGEMENTS VARY WITH DIFFERENT SERVING UTILITIES. THE UTILITY MAY REQUIRE METER BASE MOUNTING IN THE ENCLOSURE, ON THE SIDE OR ON THE BACK OF THE ENCLOSURE. THE UTILITY MAY REQUIRE THE DIMENSION BETWEEN THE DOOR AND THE FRONT OF THE SAFETY SOCKET BOX TO BE LESS THAN THE 11 INCHES SHOWN IN THE LEFT SIDE- SAFETY SOCKET BOX MOUNTING DETAIL. SEE STANDARD PLAN J-3b FOR SAFETY SOCKET BOX DETAIL. THE CONTRACTOR SHALL VERIFY THE SERVING UTILITY'S REQUIREMENTS PRIOR TO FABRICATION OF AND INSTALLING THE SERVICE EQUIPMENT.
7. DIMENSIONS SHOWN ARE MINIMUM AND SHALL BE ADJUSTED TO ACCOMMODATE THE VARIOUS SIZES OF EQUIPMENT INSTALLED.
8. ALL BUSSWORK SHALL BE HIGH GRADE COPPER AND SHALL EQUAL OR EXCEED THE MAIN BREAKER RATING. ALL BREAKERS SHALL BOLT ONTO THE BUSSWORK. JUMPERING OF BREAKERS SHALL NOT BE ALLOWED. BUSSWORK SHALL ACCOMMODATE ALL FUTURE EQUIPMENT AS SHOWN IN THE BREAKER SCHEDULE.
9. THE PHOTOCELL UNIT SHALL BE CENTERED IN THE PHOTOCELL ENCLOSURE TO PERMIT 360 DEGREE ROTATION OF THE PHOTOCELL WITHOUT REMOVAL OF THE PHOTOCELL UNIT OR PHOTOCELL ENCLOSURE.
10. ALL INTERNAL WIRE RUNS SHALL BE IDENTIFIED WITH "TO - FROM" CODED TAGS LABELED WITH THE CODE LETTERS AND/OR NUMBERS SHOWN ON THE SCHEDULES. APPROVED PVC OR POLYOLEFIN WIRE MARKING SLEEVES SHALL BE USED.
11. ALL NUTS, BOLTS AND WASHERS USED FOR MOUNTING THE PHOTOCELL ENCLOSURE SHALL BE STAINLESS STEEL.
12. A 1% TOLERANCE IS ALLOWED FOR ALL DIMENSIONS.
13. THE PHOTOCELL CIRCUIT SHALL BE INSTALLED IN FLEX CONDUIT WITHIN THE METER COMPARTMENT.
14. INSTALL CONDUIT COUPLINGS ON ALL CONDUITS. PLACE COUPLINGS FLUSH WITH TOP OF CONCRETE FOUNDATION.
15. SEE PLANS FOR BREAKER SCHEDULE.
16. SEAL CABINET TO FOUNDATION WITH A 1/2" BEAD OF SILICONE. APPLY SILICONE TO DRY SURFACE ONLY.
17. THE METER BASE PORTION OF THIS SERVICE WAS DESIGNED TO MEET METERING PORTION OF EUSERC DRAWING 309 REQUIREMENTS.

KEY

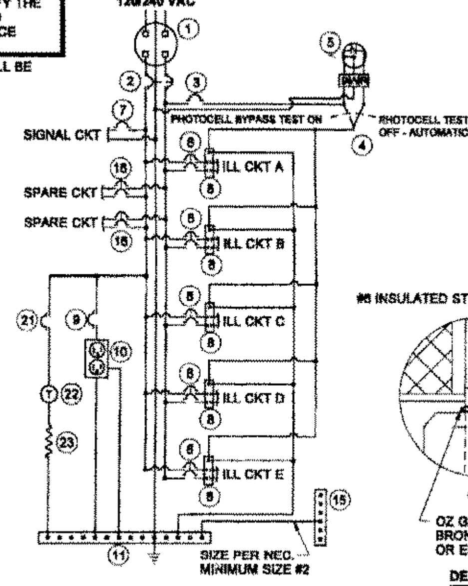
1. METER BASE PER SERVING UTILITY REQUIREMENTS. AS A MINIMUM, THE METER BASE SHALL BE SAFETY SOCKET BOX WITH FACTORY INSTALLED TEST BYPASS FACILITY THAT MEETS THE REQUIREMENTS OF EUSERC DRAWING 305.
2. MAIN BREAKER (SEE BREAKER SCHEDULE)
3. PHOTOCELL BREAKER (SPST 15 AMP - 120/240 VOLT)
4. TEST SWITCH (SPDT SNAP ACTION, POSITIVE CLOSE, 15 AMP - 120/277 VOLT "T" RATED)
5. PHOTOELECTRIC CONTROL, STD. SPEC. 9 - 29.11(2)
6. BRANCH BREAKER (SEE BREAKER SCHEDULE)
7. SIGNAL BREAKER (SEE BREAKER SCHEDULE)
8. CONTACTOR (SEE BREAKER SCHEDULE)
9. RECEPTACLE BREAKER (SPST 20 AMP - 120/240 VOLT)
10. RECEPTACLE, GROUNDED (GFCI 20 AMP - 125 VOLT)
11. NEUTRAL BUSS, 14 LUG COPPER
12. PHOTOCELL ENCLOSURE - ENCLOSURE TO BE FABRICATED FROM 5/8" EXPANDED STEEL MESH WITH WELDED SEAMS AND MOUNTING FLANGES. HOT DIP GALVANIZED AFTER FABRICATION. TYPE 5052 - H32 ALUMINUM WITH 5/8" x 5/8" OPENINGS EQUIVALENT TO 5/8" EXPANDED STEEL MESH MAY BE USED AS ALTERNATIVE MATERIAL. SEE PHOTOCELL ENCLOSURE MOUNTING DETAILS, STANDARD PLAN J-3b.
13. HINGED FRONT FACING DOOR WITH 4" x 4" MIN. POLISHED WIRE GLASS WINDOW.
14. HINGED DEAD FRONT WITH 1/4 TURN FASTENERS OR SLIDE LATCH.
15. CABINET MAIN BONDING JUMPER. BUSS SHALL BE 4 LUG TINNED COPPER. SEE CABINET MAIN BONDING JUMPER DETAIL, STANDARD PLAN J-3b.
16. SPARE BRANCH BREAKER (DPST 20AMP- 120/240 VOLT)
17. METAL WIRING DIAGRAM HOLDER
18. REMOVABLE EQUIPMENT MOUNTING PAN
19. 6" x 6" MIN. UNDERGROUND FEED - SERVICE WIREWAY (LEFT REAR CORNER)
20. SCREENED VENTS, 2 REQUIRED, 1 EACH SIDE, LOUVERED PLATES.
21. HEATER BREAKER (SPST 15 AMP - 120/240 VOLT)
22. THERMOSTAT, 40°F CLOSURE - 3 DIFFERENTIAL
23. STRIP HEATER (100 WATT NOMINAL), WITH TERMINAL STRIP COVER.
24. 24 CIRCUIT PANEL BOARD - MINIMUM SIZE WITH SEPARATE MAIN BREAKER.
25. LABEL CABINET WITH BUSSWORK RATING.



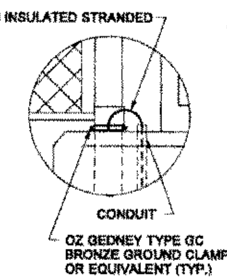
SERVICE CABINET



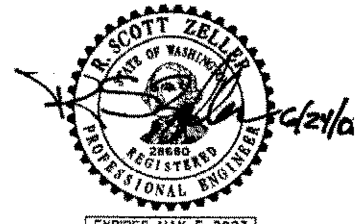
PLAN VIEW



WIRING SCHEMATIC



DETAIL A



EXPIRES MAY 5, 2003

SERVICE CABINET TYPE D (0 - 200 AMP TYPE 120/240 SINGLE PHASE)

STANDARD PLAN J-3c

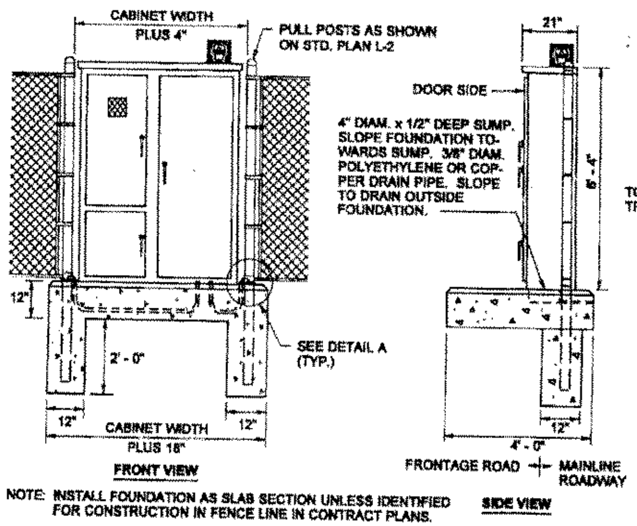
SHEET 1 OF 1 SHEET

APPROVED FOR PUBLICATION

6-24-02

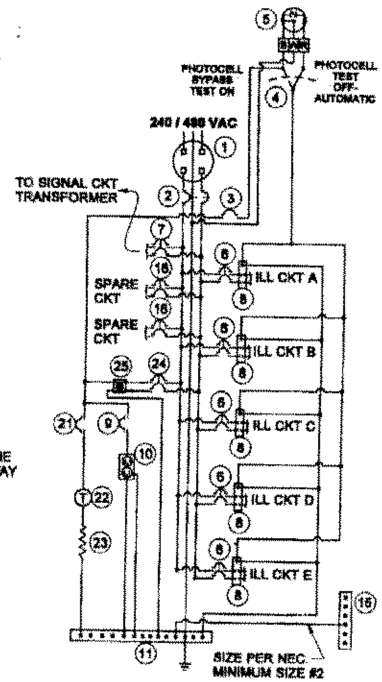
STATE DESIGN ENGINEER DATE

Washington State Department of Transportation

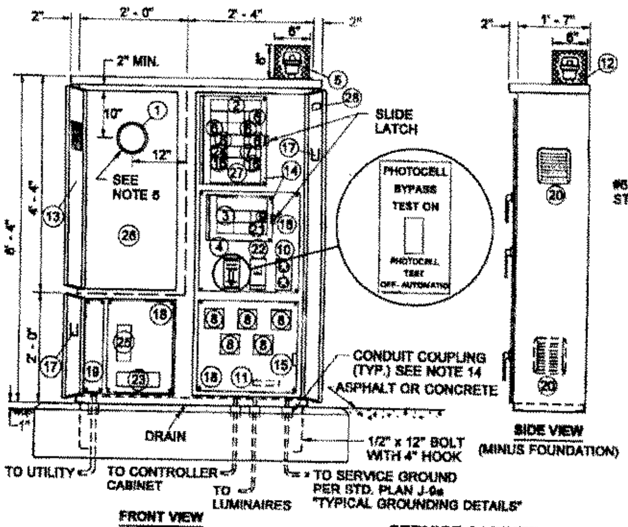


NOTE: INSTALL FOUNDATION AS SLAB SECTION UNLESS IDENTIFIED FOR CONSTRUCTION IN FENCE LINE IN CONTRACT PLANS.

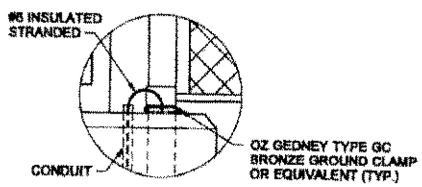
INSTALLATION DETAIL



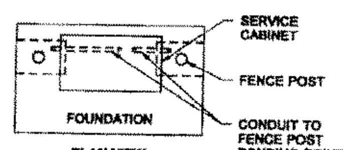
WIRING SCHEMATIC



SERVICE CABINET



DETAIL A



PLAN VIEW

KEY

1. METER BASE PER SERVING UTILITY REQUIREMENTS. AS A MINIMUM, THE METER BASE SHALL BE SAFETY SOCKET BOX WITH FACTORY INSTALLED TEST BYPASS FACILITY THAT MEETS THE REQUIREMENTS OF EUSERC DRAWING 305.
2. MAIN BREAKER (SEE BREAKER SCHEDULE)
3. PHOTOCELL BREAKER (SPST 15 AMP - 120/240 VOLT)
4. TEST SWITCH (SPDT SNAP ACTION, POSITIVE CLOSE 15 AMP - 120/277 VOLT "T" RATED)
5. PHOTOELECTRIC CONTROL, STD. SPEC. 9 - 29.11(2)
6. BRANCH BREAKER (SEE BREAKER SCHEDULE)
7. SIGNAL TRANSFORMER BREAKER (SEE BREAKER SCHEDULE)
8. CONTACTOR (SEE BREAKER SCHEDULE)
9. RECEPTACLE BREAKER (SPST 20 AMP - 120/240 VOLT)
10. RECEPTACLE, GROUNDED (GFCI 20 AMP - 125 VOLT)
11. NEUTRAL BUSS, 14 LUG COPPER
12. PHOTOCELL ENCLOSURE - ENCLOSURE TO BE FABRICATED FROM 5/8" EXPANDED STEEL MESH WITH WELDED SEAMS AND MOUNTING FLANGES. HOT DIP GALVANIZED AFTER FABRICATION. TYPE 5052 - H32 ALUMINUM WITH 5/8" x 5/8" OPENINGS EQUIVALENT TO 5/8" EXPANDED STEEL MESH MAY BE USED AS ALTERNATIVE MATERIAL. SEE PHOTOCELL ENCLOSURE MOUNTING DETAILS, STANDARD PLAN J-3b.
13. HINGED FRONT FACING DOOR WITH 4" x 4" MIN. POLISHED WIRE GLASS WINDOW.
14. HINGED DEAD FRONT WITH 1/4 TURN FASTENERS OR SLIDE LATCH
15. CABINET MAIN BONDING JUMPER. BUSS SHALL BE 4 LUG TINNED COPPER. SEE CABINET MAIN BONDING JUMPER DETAIL, STANDARD PLAN J-3b.
16. SPARE BRANCH BREAKER (DPST-20AMP- 240/480 VOLT)
17. METAL WIRING DIAGRAM HOLDER
18. REMOVABLE EQUIPMENT MOUNTING PAN
19. 8" x 8" MIN. UNDERGROUND FEED - SERVICE WIREWAY (LEFT REAR CORNER)
20. SCREENED VENTS, 2 REQUIRED, 1 EACH SIDE, LOUVERED PLATES
21. HEATER BREAKER (SPST 15 AMP - 120/240 VOLT)
22. THERMOSTAT, 40°F CLOSURE - 3 DIFFERENTIAL
23. STRIP HEATER (100 WATT NOMINAL), WITH TERMINAL STRIP COVER
24. TRANSFORMER BREAKER (DPST 15 AMP - 480 VOLT)
25. DRY TRANSFORMER (480/120 VOLT) 3 KVA COPPER BUSSED AND COPPER WOUND
26. RESERVED FOR METER, CURRENT TRANSFORMER AND/OR DISCONNECT SWITCH AS REQUIRED BY THE UTILITY
27. 24 CIRCUIT PANEL BOARD - MINIMUM SIZE WITH SEPARATE MAIN BREAKER.
28. LABEL CABINET WITH BUSSWORK RATING

GENERAL NOTES

200 AMP TYPE 240/480 1ø SERVICE CABINET

1. SEE STD. SPECIFICATION 9-29.24, SERVICE CABINETS.
2. HINGES SHALL HAVE STAINLESS STEEL OR BRASS PINS.
3. CABINETS SHALL BE RATED NEMA 3R AND SHALL INCLUDE TWO RAIN TIGHT VENTS.
4. METERING EQUIPMENT DOORS SHALL BE PAD LOCKABLE. EACH DOOR SHALL BE GASKETED. INSTALL BEST CX CONSTRUCTION CORE ON BOTTOM LEFT AND RIGHT DOORS. SEE DOOR HINGE DETAIL, STD. PLAN J-3b; CONCEALED HEAVY DUTY STAINLESS STEEL LIFT OFF HINGES ARE ALLOWED AS AN ALTERNATIVE. UPPER LEFT DOOR SHALL HAVE 3 HINGES, LOWER LEFT DOOR SHALL HAVE 2 HINGES, AND RIGHT DOOR SHALL HAVE 3 HINGES. LOWER DOOR SHALL HAVE A TWO POSITION DOOR STOP ASSEMBLY.
5. THE FOLLOWING EQUIPMENT WITHIN THE SERVICE ENCLOSURE SHALL HAVE AN APPROPRIATELY ENGRAVED PHENOLIC NAME PLATE ATTACHED WITH SCREWS OR RIVETS: KEY NUMBERS 2, 3, 4, 6, 7, 8, 9, 16, 21 AND 25. KEY NUMBER 4 NAME PLATE SHALL READ: "PHOTOCELL BYPASS TEST ON" AND "PHOTOCELL TEST OFF- AUTOMATIC". SEE SERVICE CABINET DETAIL.
6. METERING ARRANGEMENTS VARY WITH DIFFERENT SERVING UTILITIES. THE UTILITY MAY REQUIRE METER BASE MOUNTING IN THE ENCLOSURE, ON THE SIDE, OR ON THE BACK OF THE ENCLOSURE. THE UTILITY MAY REQUIRE THE DIMENSION BETWEEN THE DOOR AND THE FRONT OF THE SAFETY SOCKET BOX TO BE LESS THAN THE 11 INCHES SHOWN IN THE LEFT SIDE- SAFETY SOCKET BOX MOUNTING DETAIL, SEE STD. PLAN J-3b. THE CONTRACTOR SHALL VERIFY THE SERVING UTILITY'S REQUIREMENTS PRIOR TO FABRICATION OF AND INSTALLING THE SERVICE EQUIPMENT.
7. THE DIMENSIONS SHOWN ARE MINIMUM AND SHALL BE ADJUSTED TO ACCOMMODATE THE VARIOUS SIZES OF EQUIPMENT INSTALLED.
8. ALL BUSSWORK SHALL BE HIGH GRADE COPPER AND SHALL EQUAL OR EXCEED THE MAIN BREAKER RATING. ALL BREAKERS SHALL BOLT ONTO THE BUSSWORK. JUMPERING OF BREAKERS SHALL NOT BE ALLOWED. BUSSWORK SHALL ACCOMMODATE ALL FUTURE EQUIPMENT AS SHOWN IN THE BREAKER SCHEDULE.
9. THE PHOTOCELL UNIT SHALL BE CENTERED IN THE PHOTOCELL ENCLOSURE TO PERMIT 360 DEGREE ROTATION OF THE PHOTOCELL WITHOUT REMOVAL OF THE PHOTOCELL UNIT OR THE PHOTOCELL ENCLOSURE.
10. ALL INTERNAL WIRE RUNS SHALL BE IDENTIFIED WITH "TO - FROM" CODED TAGS LABELED WITH THE CODE LETTERS AND/OR NUMBERS SHOWN ON THE SCHEDULES. APPROVED PVC OR POLYOLEFIN WIRE MARKING SLEEVES SHALL BE USED.
11. ALL NUTS, BOLTS, AND WASHERS USED FOR MOUNTING PHOTOCELL ENCLOSURE SHALL BE STAINLESS STEEL.
12. A 1% TOLERANCE IS ALLOWED FOR ALL DIMENSIONS.
13. SEE PLANS FOR BREAKER SCHEDULE.
14. INSTALL CONDUIT COUPLINGS ON ALL CONDUITS. PLACE COUPLINGS FLUSH WITH TOP OF CONCRETE FOUNDATION.
15. SEAL CABINET TO FOUNDATION WITH A 1/2" BEAD OF SILICONE. APPLY SILICONE TO DRY SURFACE ONLY.
16. THE METER BASE PORTION OF THIS SERVICE WAS DESIGNED TO MEET METERING PORTION OF EUSERC DRAWING 309 REQUIREMENTS.

R. SCOTT ZELLER
STATE OF WASHINGTON
28680
REGISTERED PROFESSIONAL ENGINEER
10-31-03
EXPIRES MAY 5, 2005

SERVICE CABINET TYPE E (0 - 200 AMP TYPE 240/480 SINGLE PHASE)

STANDARD PLAN J-3d

SHEET 1 OF 1 SHEET

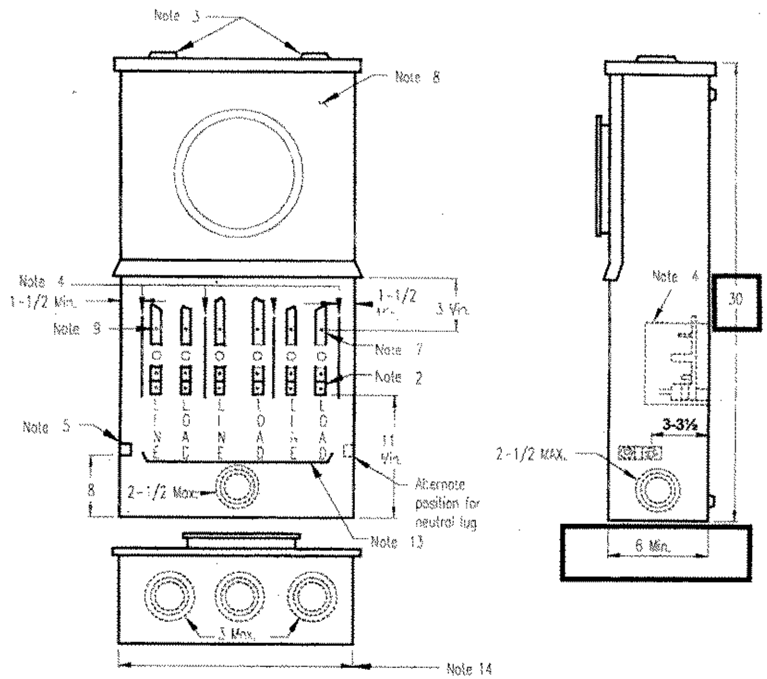
APPROVED FOR PUBLICATION

11-5-03

STATE DESIGN ENGINEER | DATE

Washington State Department of Transportation

DATE	REVISION	BY
09/2003	REVISED KEY NOTE 16	MHS



ALL DIMENSIONS SHOWN ARE IN INCHES

NOTES:

1. This device may be used for commercial, multifamily residential (not separately metered) and other types of occupancies.
2. Cable terminating facilities shall be aluminum bodied mechanical lugs with a range of No. 1/0 AWG through No. 250 Kcmil.
3. Hubs capped off if used for underground feed.
4. Rigid insulating barriers.
5. Insulated bondable vertical lay-in, double neutral lug with No. 250 Kcmil wire capacity, mounted on either sidewall.
6. Test-bypass blocks shall be bussed or wired to socket jaws or terminals.
7. Upper test connector studs.

REV.	DATE	DESCRIPTION
1	02/89	NOTES 10, 11, 12 & 14. ADDED COLOR SPECIFICATIONS.
2	06/90	ADDED NOTE 16.
3	08/97	REVISE LUG DESIGNATION IN NOTE 2 - PROJECT 961120

SCALE	SAFETY SOCKET BOX WITH FACTORY INSTALLED TEST-BYPASS FACILITIES, 200 AMPERE, 0-600 VOLTS	SH 1 OF 2 SH	
DATE 08/97	ELECTRIC UTILITY SERVICE EQUIPMENT REQUIREMENTS COMMITTEE	DWG NO 305	REV. 3

8. All panels shall be independently removable. Meter panel shall be provided with a sealing ring and the meter socket shall be rigidly mounted on support and attached to the meter panel. Test-bypass compartment cover panel shall be sealable and permanently labeled: "DO NOT BREAK SEALS. NO FUSES INSIDE".

9. Test-bypass block detail on Dwg. 312.

10. For 3-Phase, 4 wire, connect 7th jaw to body of neutral lug with No. 12 Min. copper wire, white in color.

11. For 3-Phase, 4 wire delta, identify right hand test-bypass block (2 poles) as power leg. Identification to be orange in color.

12. For 3-Phase, 3 wire, install bus to connect line and load poles together at top of center test-bypass block and connect 5th jaw to this bus, using No. 12 Min. copper wire. Color shall be other than white, gray, green or orange.

13. For 1-Phase, 3 wire, provide two test-bypass blocks mounted in the outer positions and a four jaw socket.

14. For 1-Phase, 3 wire, 120/208 volt, provide two test-bypass blocks mounted in the outer positions and a five jaw socket. Connect 5th jaw of meter socket to body of neutral lug with a No. 12 Min. copper wire, white in color.

15. Decals on inside back of enclosure in 3/4 inch minimum block letter labeling.

16. Minimum width of access opening shall be 13-1/2 inches.

REV.	DATE	DESCRIPTION
1	02/89	NOTES 10, 11, 12 & 14. ADDED COLOR SPECIFICATIONS.
2	06/90	ADDED NOTE 16.
3	08/97	REVISE LUG DESIGNATION IN NOTE 2 - PROJECT 961120

SCALE	SAFETY SOCKET BOX WITH FACTORY INSTALLED TEST-BYPASS FACILITIES, 200 AMPERE, 0-600 VOLTS	SH 2 OF 2 SH	
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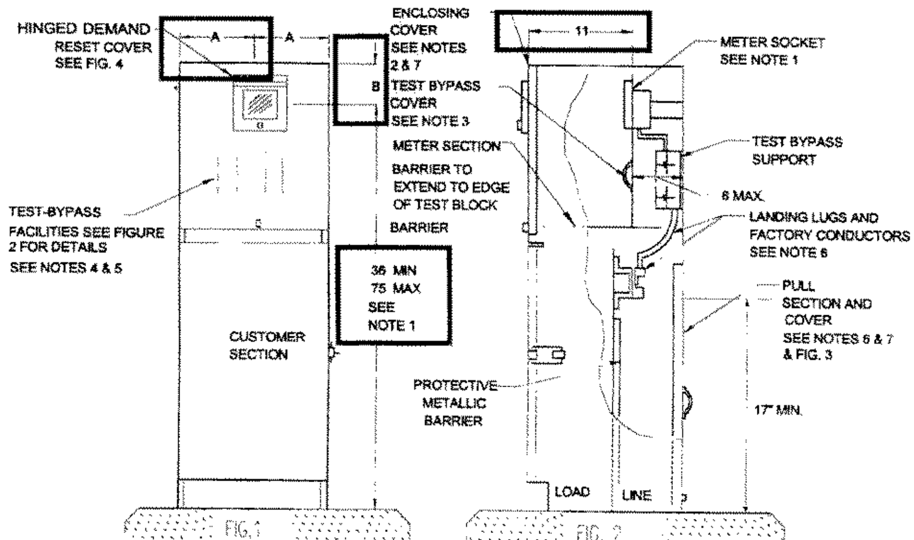


FIG. 1
FRONT VIEW

FIG. 2
SIDE VIEW

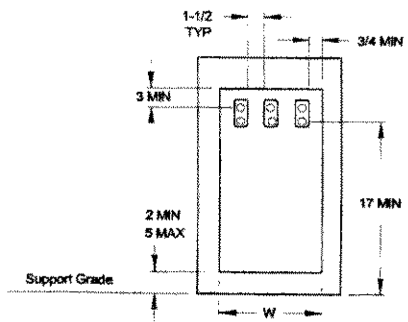


FIG. 3
WIREWAY PULL SECTION

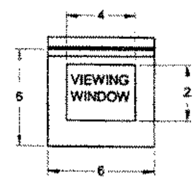


FIG. 4
HINGED DEMAND RESET
WITH POLYCARBONATE VIEWING

TABLE 1 - MINIMUM DIMENSIONS

SERVICE	W*	A**	B**
1 PHASE	10-1/2	10	9
3 PHASE	12-1/2		

* SEE NOTE 6 & 7   ** SEE NOTE 2 & 7

ALL DIMENSIONS SHOWN ARE IN INCHES

REV.	DATE	DESCRIPTION
	03/98	DRAWING ADDED - PROJECT 970509
	10/98	NEW PROJECT
	1/99	REVISION ADDED MIN DIMENSION TO TABLE 1

SCALE	COMMERICAL FIXED TOP SERVICE PEDESTALS 0-200 AMPERES 0-600 VOLTS	sheet 1 of 3	
DATE 10/98	ELECTRIC UTILITY SERVICE EQUIPMENT REQUIREMENTS COMMITTEE	DWG NO 309	REV.

NOTES:

1. The meter panel shall be provided with a sealing ring and the meter socket shall be rigidly mounted on a support, attached to the meter panel. Ringless sockets are not acceptable. Meter height is measured from the center of the meter-socket.

2. The meter shall be enclosed and the enclosing cover shall meet the following conditions:

   a. The cover shall have a fixed top and sides with access to the metering compartment provided through a hinged door. The hinged door shall be equipped with a device to hold the door in the open position at 90 degrees or more.

> Note: "A" and "B" dimensions are measured from the center of the meter socket to the access opening return flanges.

3. Test-bypass compartment covers shall be sealable and fitted with a lifting handle - covers exceeding 16 inches in width shall require two lifting handles.

4. Test-bypass blocks with rigid barriers shall be furnished, installed and wired or bussed to the meter socket by the manufacturer. Connection sequences shall be LINE-LOAD from left to right and clearly identified by 3/4 inch minimum block letter labeling. See Drawings 311 and 312 for test-bypass block details.

5. Test-bypass shall be installed with the following clearances:

   a. 3-inches of vertical clearance from the upper test connector stud to the upper compartment access opening and 3-inches from the center of the cable terminal screw to the lower compartment access opening.

   b. 1-1/2 inches of side clearance from the rigid insulating barriers to the compartment sides and 1 inch to the compartment access openings.

6. The terminating pull section shall:

   a. Comply with the minimum dimensions shown in Table 1 (The "W" dimension is measured between the access opening return flanges), accept a minimum 3 inch conduit, and the cover shall be equipped with a lifting handle.

   b. Be equipped with an aluminum-bodied, mechanical lugs, with a range of No. 6 AWG through 250 Kcmil, for termination of the service conductors. Insulated cable or bus shall be installed between the termination lugs and the test-bypass facilities.

   c. Have a protective metallic barrier (16 gauge minimum) provided between the pull section and the customer distribution section. There shall be a 1/4 inch minimum clearance between the customer section wall and the barrier to prevent screws and bolts from protruding into the pull section.

7. Utility compartments covers (i.e., meter cover, demand reset cover, and pull section) shall be sealable and lockable with a padlock having a 5/16 inch lockshaft.

REV.	DATE	DESCRIPTION
	03/98	DRAWING ADDED - PROJECT 970509
	10/98	NEW PROJECT
	1/99	REVISION ADDED MIN DIMENSION TO TABLE 1

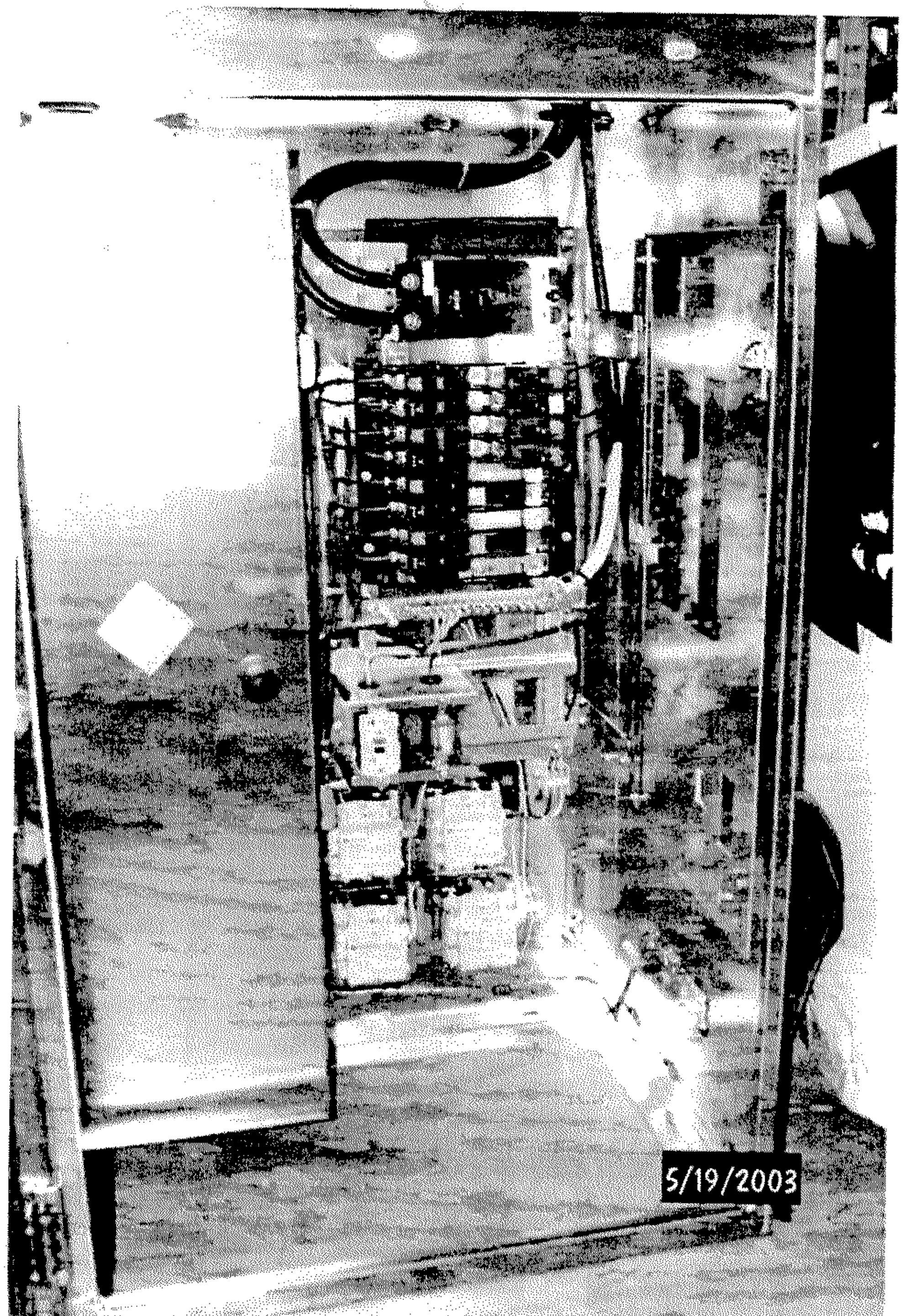
SCALE	COMMERICAL FIXED TOP SERVICE PEDESTALS 0-200 AMPERES 0-600 VOLTS	sheet 1 of 3	
DATE 10/98	ELECTRIC UTILITY SERVICE EQUIPMENT REQUIREMENTS COMMITTEE	DWG NO 309	REV.

8. Internal equipment attached to the outer walls of the enclosure shall be secured in place with devices that may not be loosened from the outside. Screws or bolts requiring special tools for installation or removal are not acceptable.

9. For structural mounting and support of the pedestal consult the serving agency.

REV.	DATE	DESCRIPTION
	03/98	DRAWING ADDED - PROJECT 970509
	10/98	NEW PROJECT
	1/99	REVISION ADDED MIN DIMENSION TO TABLE 1

SCALE	**COMMERICAL FIXED TOP SERVICE PEDESTALS** **0-200 AMPERES 0-600 VOLTS**	sheet 1 of 3	
DATE 10/98	**ELECTRIC UTILITY SERVICE EQUIPMENT REQUIREMENTS COMMITTEE**	DWG NO **309**	REV.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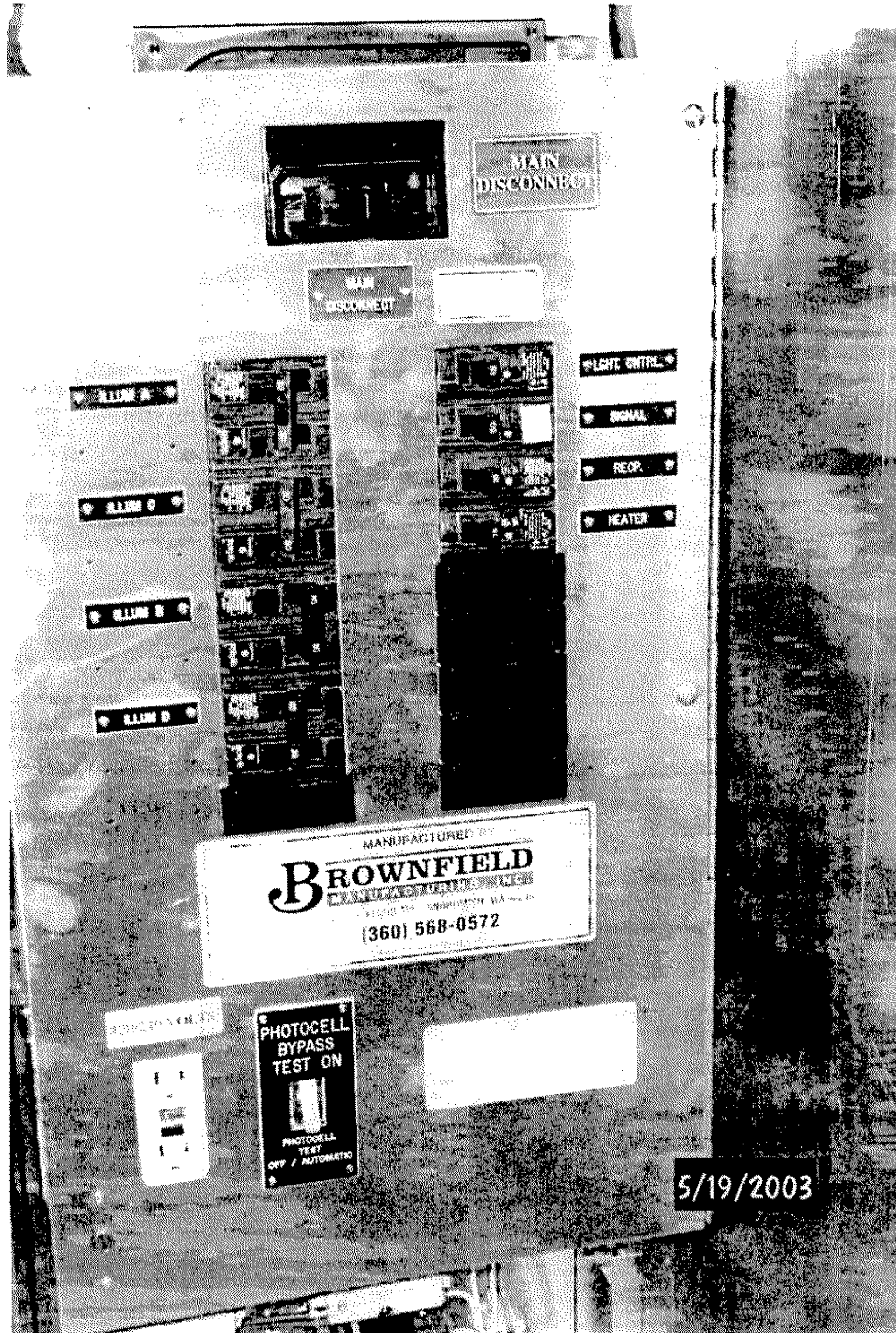
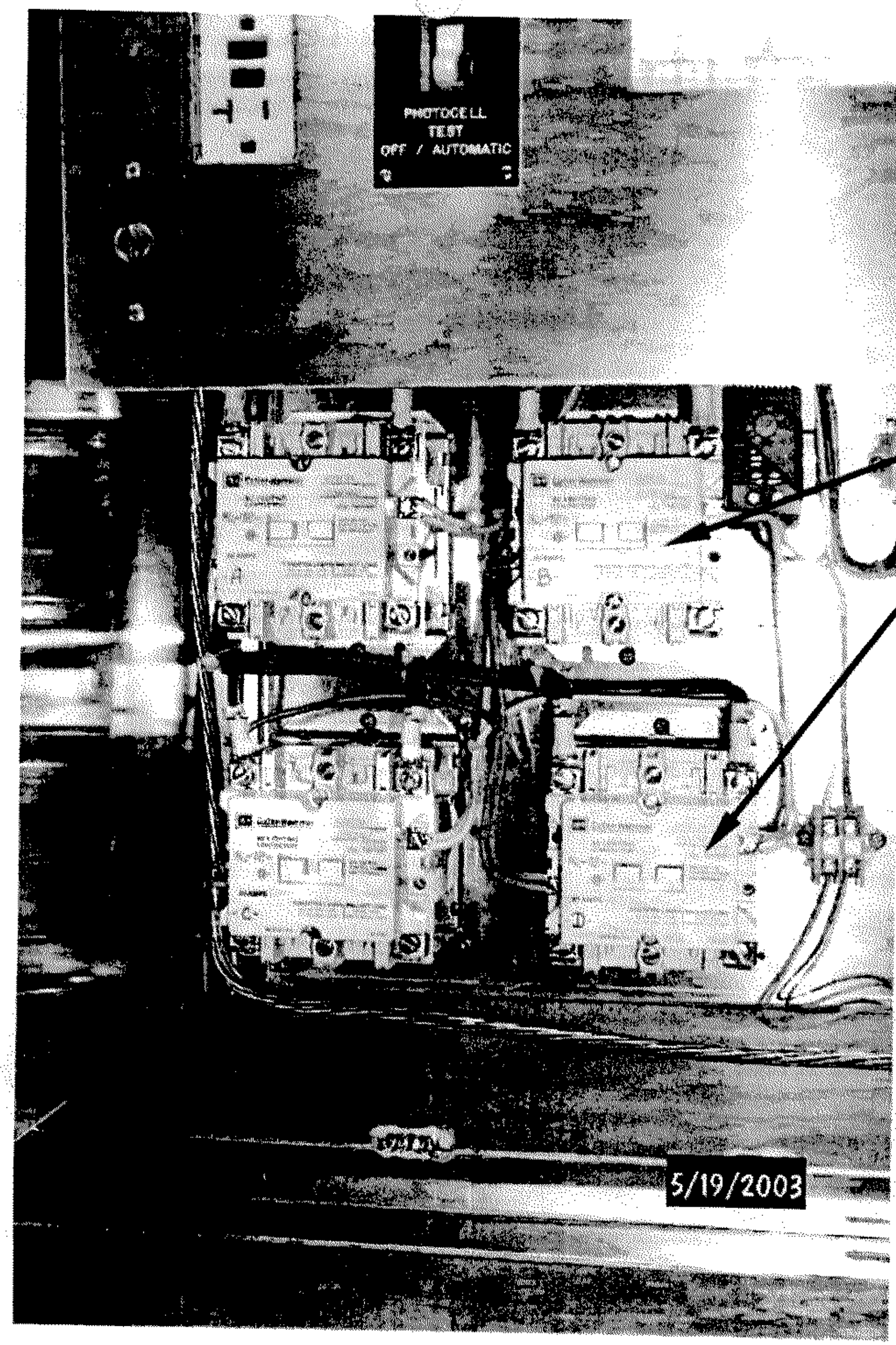
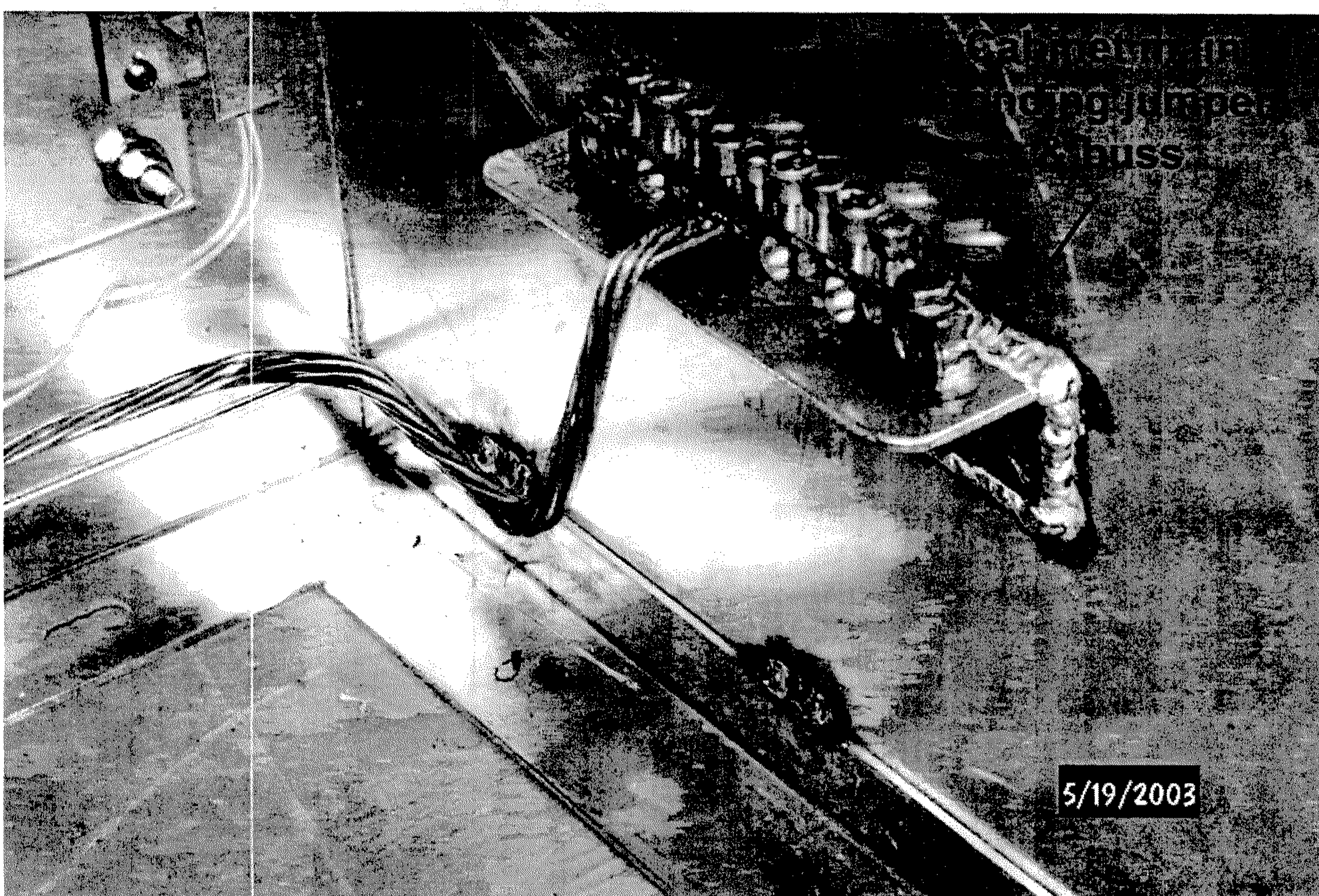
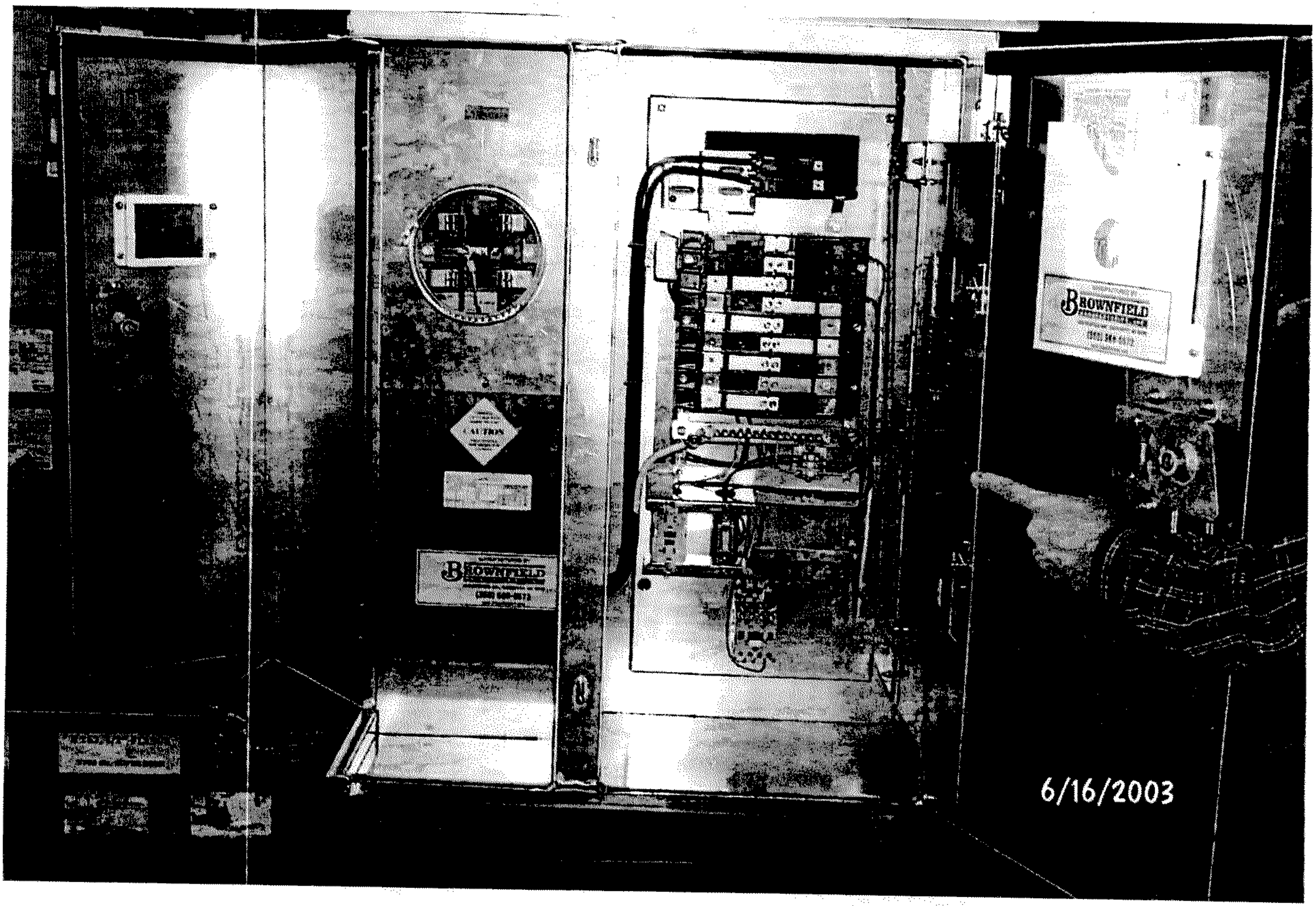


MAIN DISCONNECT
MAIN DISCONNECT
LIGHT CNTRL
SIGNAL
RECP.
HEATER
MANUFACTURED BY
BROWNFIELD
(360) 568-0572
PHOTOCELL BYPASS TEST ON
5/19/2003



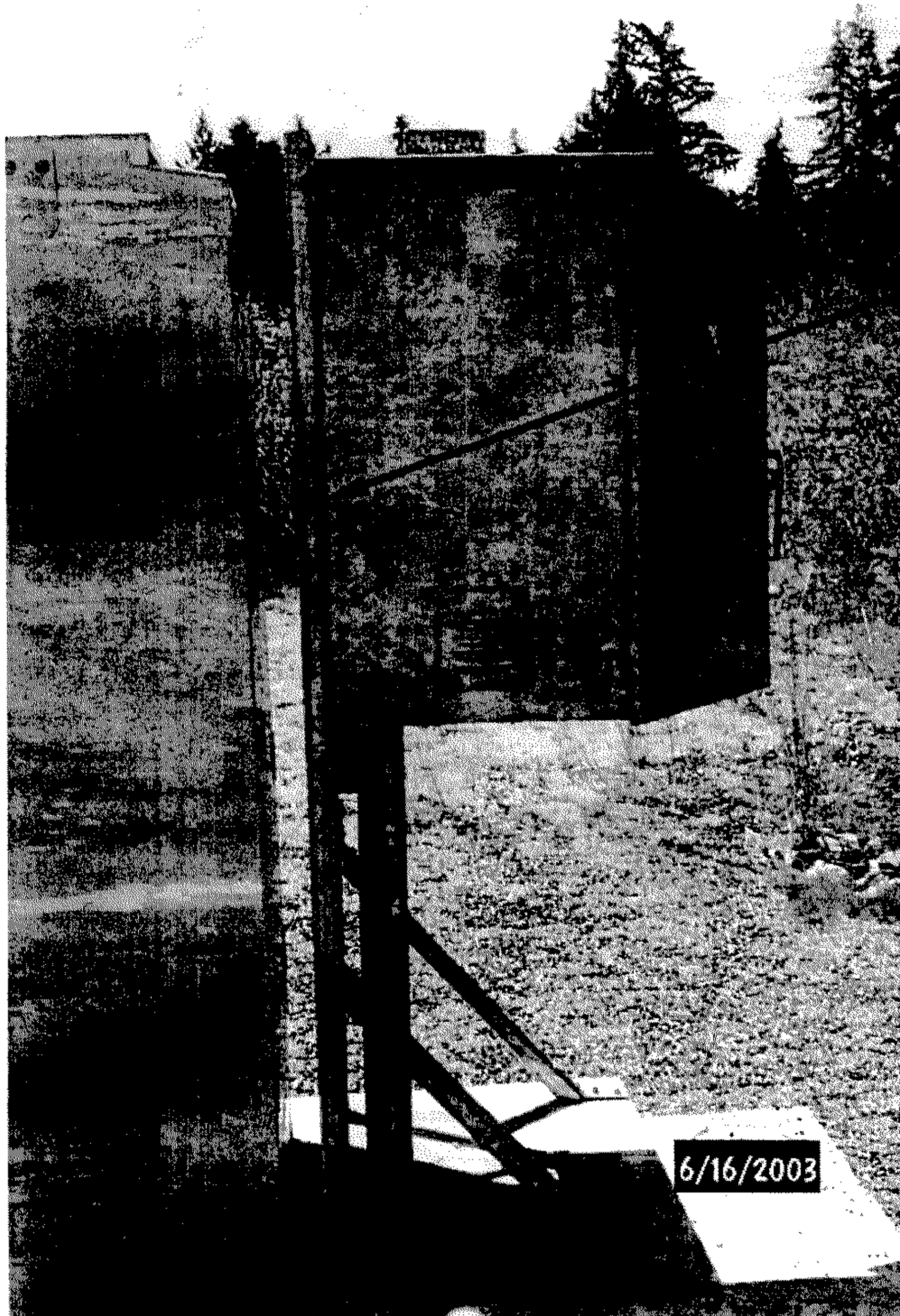
Lighting contactors


buss
5/19/2003

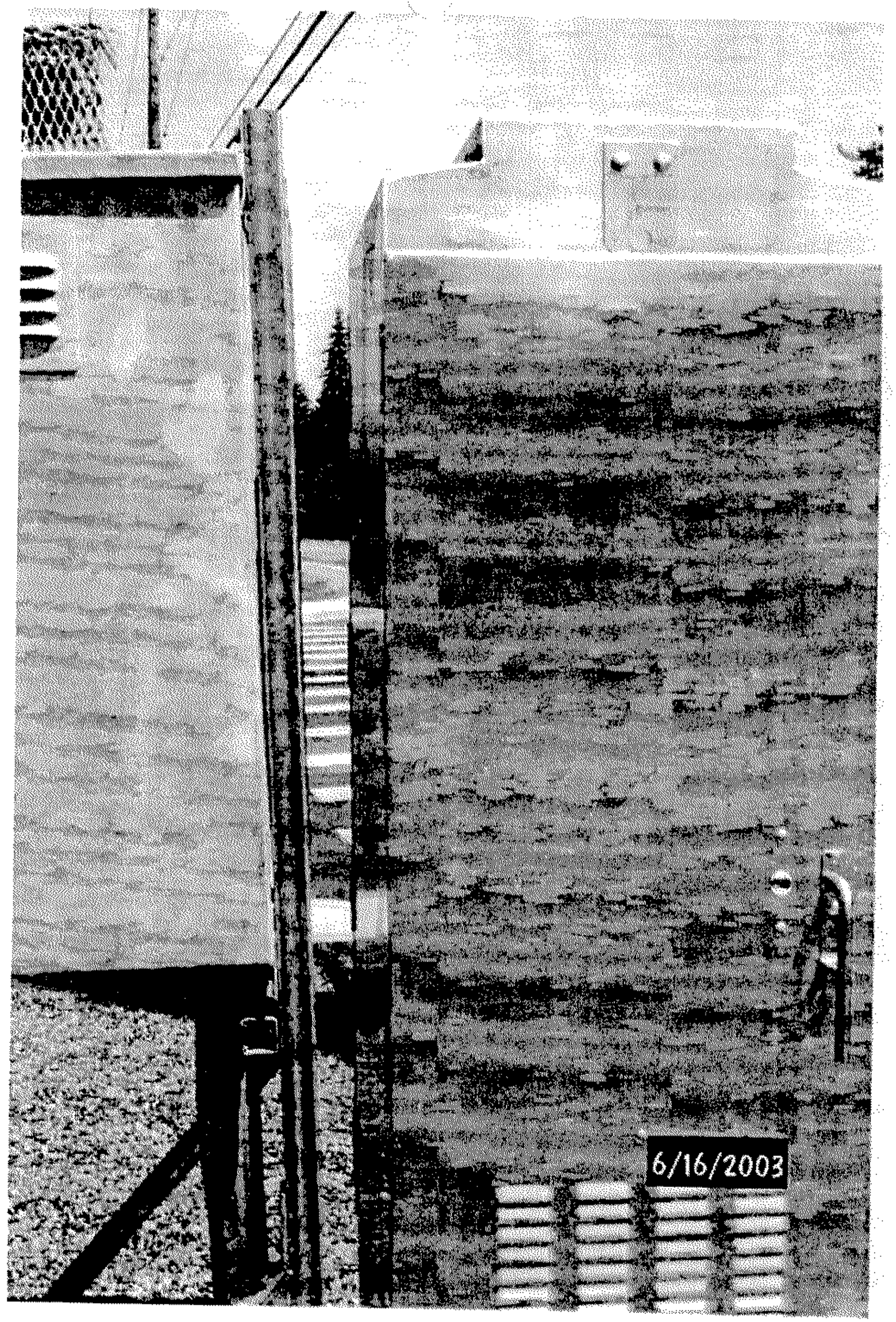

BROWNFIELD
BROWNFIELD
6/16/2003


MAIN DISCONNECT
PHOTOCELL BYPASS TEST ON
CAUTION
BROWNFIELD
6/16/2003

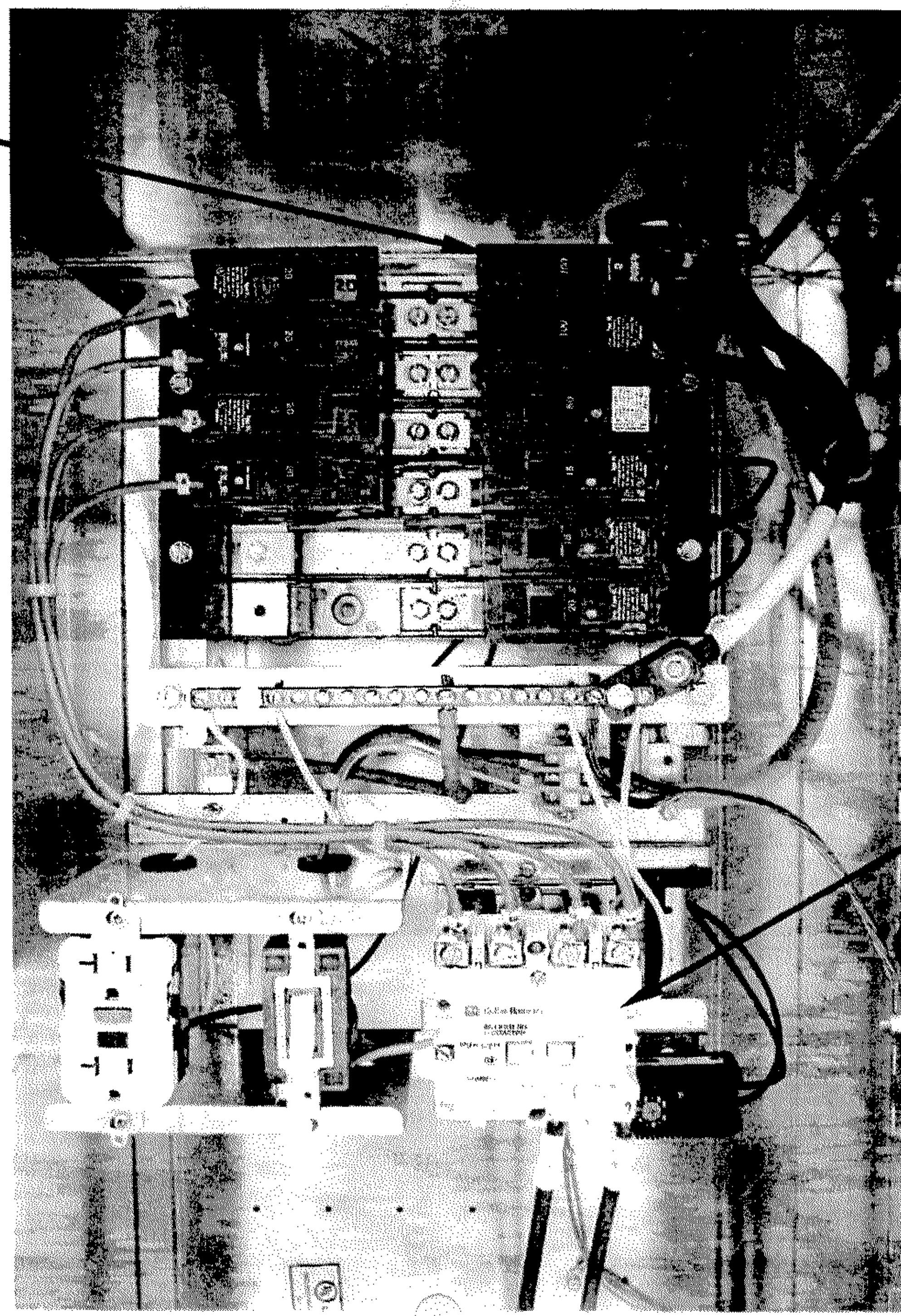

CAUTION
BROWNFIELD
(360) 568-0572
6/16/2003



This slotted steel channel is specified as 1-5/8" x 2-7/16" not 1-5/8" x 1-5/8"

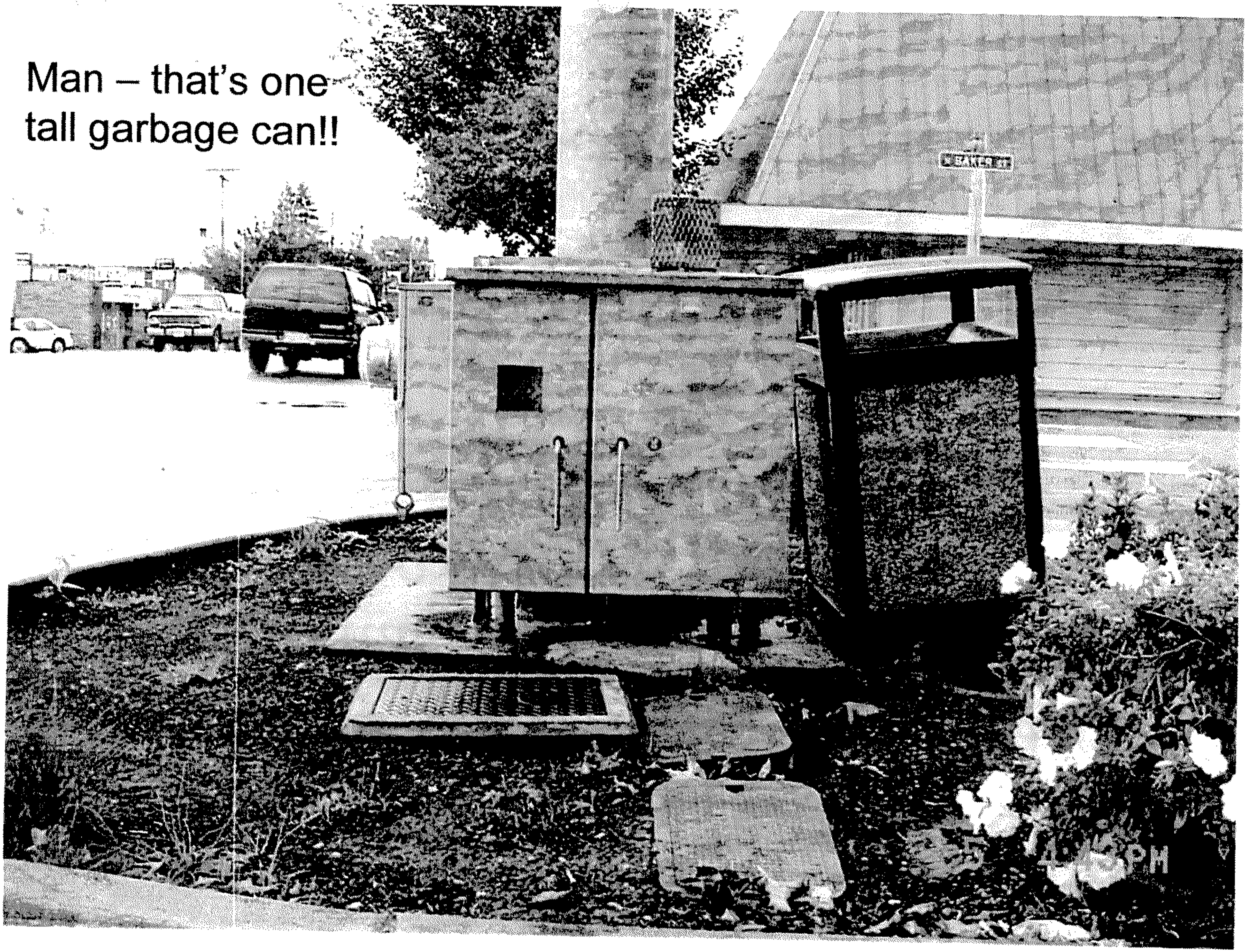

6/16/2003

Back-fed
main breaker
(not acceptable)



Dual circuit
contactor
(not acceptable)

Man – that's one tall garbage can!!



If you have any questions, please contact Terry Thayer at:
360-705-7290